MARCH 1941

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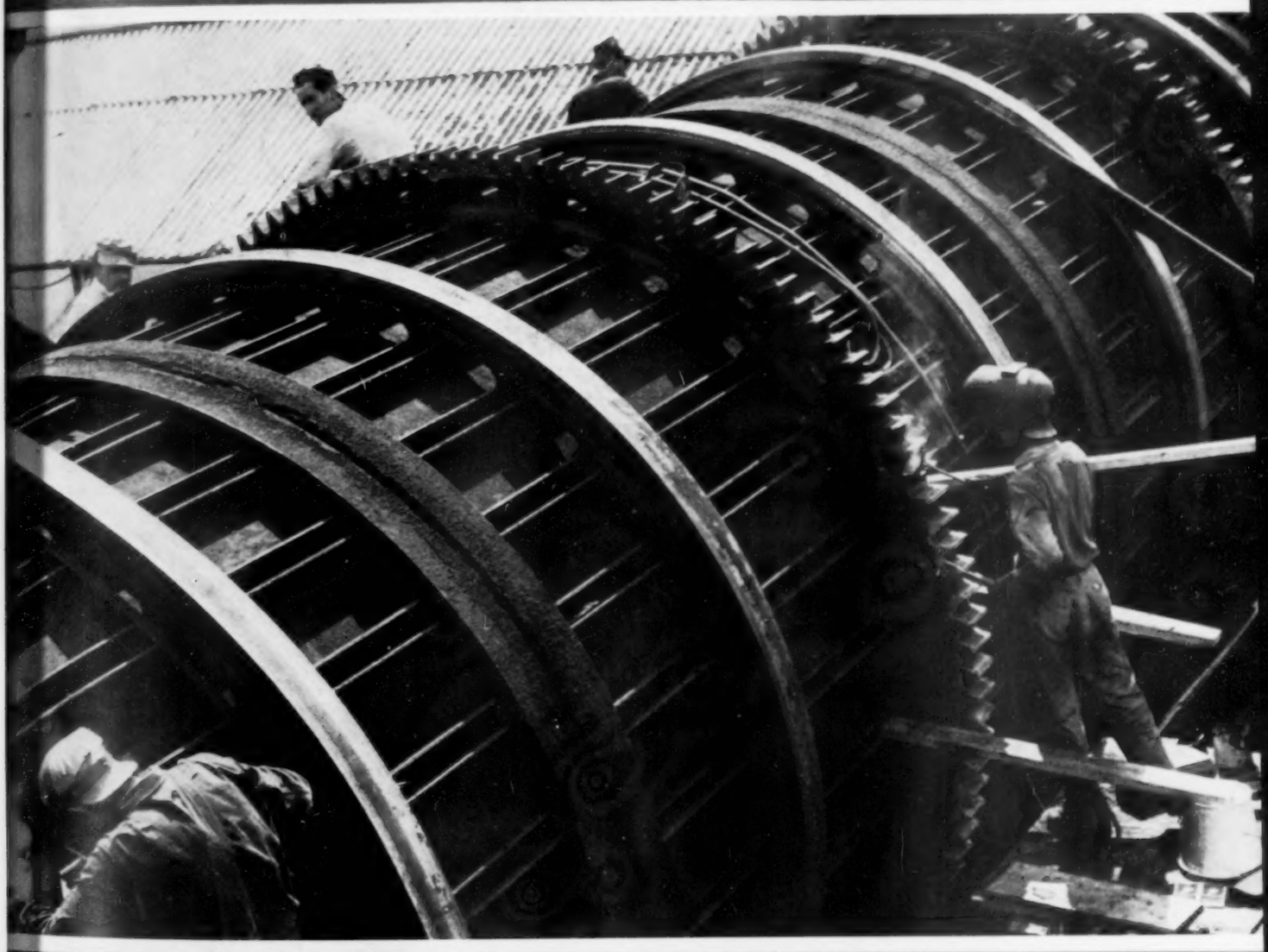
The WELDING Journal



The Journal of the American Welding Society

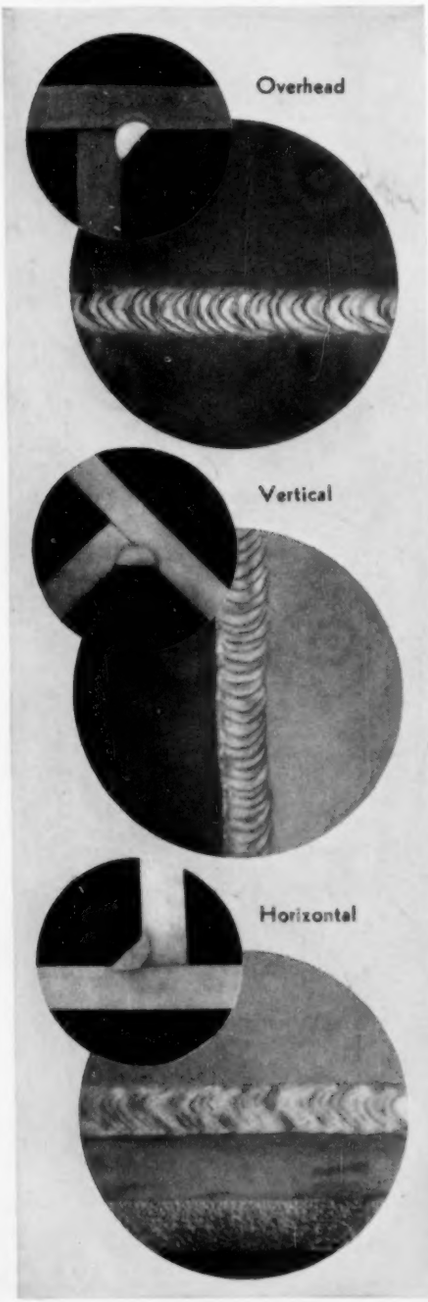
WHY G-E ELECTRODE W-22 GIVES YOU

INCREASED SPEEDS

ON QUALITY WELDS

. . . 8 per cent Faster Deposition

Photos of W-22 Welds



HERE'S a fully approved reverse-polarity, all-position rod for welding hulls, structural members, bulkheads, stiffeners, subassemblies, engine-bases, and other marine work that really helps operators produce faster and better welds.

Welding operators agree, when they use this rod, that it is especially **fast** and **"easy to handle,"** producing welds of **excellent contour** and **appearance.**

SPEED

Comparisons of carefully measured deposition rates at the same power levels (amperes times arc volts), in all positions, show a difference of 5 to 8 per cent in favor of Type W-22 electrode. Overall welding speed is further increased because this electrode is so easy to handle. Molten weld metal crosses the arc in a fine spray instead of large drops—a feature of great help to the operator in making uniform welds and in avoiding any tendency of the electrode to stick to the work, especially on vertical and overhead joints.

Pleasing Appearance and Flat Contour Obtained with the W-22 Electrode

The flat contour of deposit obtained with Type W-22 helps to avoid stress concentrations by distributing stresses evenly. It also avoids the waste weld metal represented by a convex contour—a saving which may amount to as much as 20 or 30% on overhead joints. The thorough penetration into the root of the joint develops full strength, and the even ripple of the head produces a finish of which any operator can be proud.

Approvals: This electrode is approved by:
Bureau of Marine Inspection and Navigation
American Bureau of Shipping, Groups H1G and B1G
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Qualifications, it will meet:
A.W.S. Filler Metal Specification E-6010
A.S.M.E. Boiler Code, Paragraphs U-68, U-69, and U-70

It will meet the requirements of U.S. Navy Specifications 22-W-7, Class 1, and is permitted on work requiring approval of Hartford Steam Boiler Inspection and Insurance Company.

Complete engineering data and test results of welding speeds, physical qualities, etc., are available through your local G-E arc welding distributor or G-E Sales Office. Call or write them today for a free demonstration of this electrode applied to your own work.

Type W-22 is today's best answer to the profit formula for electrodes: MAXIMUM DEPOSITION RATE × MAXIMUM USABILITY = MAXIMUM WELDING SPEED

GENERAL ELECTRIC

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A Program for Training Arc Welding Operators on the Job

By Elmer E. Isgren* and Walter J. Brooking†

THE rapid growth of the Peoria plant of R. G. LeTourneau, Inc., from half a dozen welding operators in the spring of 1935 to about 500 operators in 1940 has almost of necessity predisposed the Company to a program of welding operator training. In addition to the rapid growth, the fact that most of the units of equipment which are produced in the plant are built in quantities of from 10 to 100 units at a time allows the organization to apply the principles of mass production to the fabrication process to such a degree that the LeTourneau welding operator is a specialized workman whose training has to be obtained in the LeTourneau plant to a large extent.

The direct result of the application of mass production principles has been the establishment of complete procedure control for operations on all production items. This procedure control is begun by building fixtures for the setting up and the most favorable positioning during welding for all sub-structures and structures which comprise the unit; with a planned and written, step-by-step procedure from start to finish for each sub-structure or structure. The actual weld metal depositing procedure control is achieved by the use of the A. W. S. Arc Welding Symbols on the blueprint, plus additions to the basic symbol which specifies to the operator the following information for every weld on his work:

1. Location of weld.
2. Size of weld.
3. Cross-sectional view (type) of weld.
4. Position in which the weld is deposited (i.e. flat, horizontal fillet, etc.).
5. Number of passes in the weld.
6. Type of electrode to be used for each pass in the weld.
7. Size of electrode to be used for each pass in the weld.
8. Machine setting for each pass in the weld.

This complete and specific control necessitates training which cannot be obtained fully anywhere but within the Company's organization.

Three other factors make the operator a specialized workman: First, all regular production welding except the application of hardfacing to the cutter blades is done with alternating current. Most of it is done with high frequency motor generator type machines. Second, almost all steel used in the plant is a special alloy steel for which the Company has developed its own special electrodes. Third, the complete procedure control on all production jobs enables the satisfactory use of an incentive system which enables the welding operator to earn a weekly bonus, based on the amount of work produced as indicated by time studies on each unit of equipment which is built.

As a result of the foregoing special factors the Company has found that to start with a man who has had no previous welding experience and train him specifically in the Company's methods of fabrication is as effective and satisfactory from all points of view as any other way of securing welding operators.

An orderly and thorough training program for welding operators has therefore been developed and has been employed in the training of all welding operators required for the Company's rapidly expanding program.

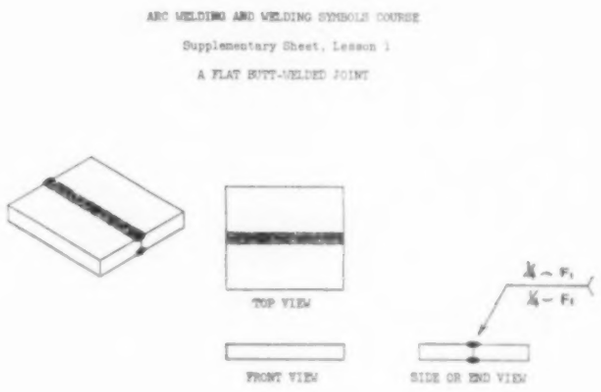
ARC WELDING AND WELDING SYMBOLS COURSE
Supplementary Sheet, Lesson 1
A FLAT BUTT-WELDED JOINT
TOP VIEW
FRONT VIEW
SIDE OR END VIEW
TWO PLATES, EDGES BUTTED TOGETHER, FUSED WITH A SINGLE FLAT BEAD ON EACH SIDE OF THE PLATE. THE WELDS SHOULD BE FUSED DEEP INTO THE PLATES. METAL PILED ABOVE THE SURFACE OF THE PLATES IS WASTED. THE WELD SHOULD BE SMOOTH AND UNIFORM IN WIDTH. THE SLAG SHOULD CLEAN OFF WITH VIGOROUS SCRAPING AFTER THE WELDED PLATES COOL. THERE SHOULD BE NO BUBBLES NOR HOLES IN THE SURFACE OF THE WELD.
THE ARROW AND SYMBOLS INDICATE THAT THERE IS A WELD ON EACH SIDE OF THE PLATE, THAT THE WELDS ARE OF 1/4" SIZE AND THAT THEY ARE WELDED AS FLAT BEADS IN ONE PASS.

Fig. 1—Theory Starts Hand in Hand with Manual Practice. The Idea of Symbols on Blueprints Is Introduced with the Elementary Names of Welds and the Essential Qualities of Welds

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† Testing & Research Dept., R. G. LeTourneau, Inc., Peoria, Ill.

The first step in the program is the hiring of the man for the definite purpose of learning to weld. Such a man is selected by the personnel department after he has qualified by meeting the requirements of mentality, education and character background expected of such an employee. He must also pass a rigid physical examination. No previous experience in welding or related to welding is required or especially desired, and often the man has had no previous factory experience of any kind.

After the student welder has been hired by the personnel department he is introduced to the Safety Engineer who gives him careful instructions as to the general safety practices carried out in the plant and special emphasis is placed on the wearing of goggles, protection from arc burn and the care of small burns which might be inflicted by bits of slag, arc explosions or large spatter drops of molten metal.

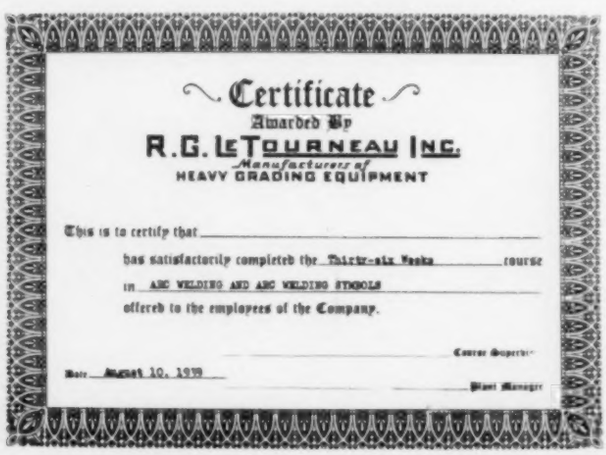
From the Safety Engineer, the student is taken for a tour of the shop by a member of the personnel staff who shows him the tool rooms, stockrooms, general layout of the plant, toilets, etc., and finally introduces him formally to the Welding Instructor. The Welding Instructor then assumes responsibility for the student welder.

The instructor's first consideration with the new student is to familiarize him with the surroundings in the instructional department and to assign a locker to him so he can feel that he has a place for both his material equipment and for his activities as an employee in an organization.

The student is then taken to the tool room where tool checks, a slagging hammer, electrode stock pot, chipping chisel and weld gage are issued to him. He then goes to the stockroom where he equips himself with safety goggles, welding helmet, gloves, sleeves and apron. The Welding Instructor carefully assists the student in adjusting his equipment to fit him and instructs him in the processes of changing helmet, lens protecting glasses and other such small, but important matters.

A certain machine in the instruction department is then assigned to the student. The instructor explains the care of the lead, tongs and machine and has the student start, stop and adjust the controls of the machine. Safety precautions are stressed pointedly again at this stage of the student's experience.

Actual welding practice then is begun. A supply of small plates upon which to weld and a quantity of electrodes of the all-position type are given to the student and the instructor establishes him in his welding booth. The process of striking, holding and breaking an arc is



Certificate

Awarded By

R. G. LeTOURNEAU INC.

Manufacturers of

HEAVY GRADING EQUIPMENT

This is to certify that _____

has satisfactorily completed the Thirty-six Weeks course

in ARC WELDING AND ARC WELDING SYMBOLS

offered to the employees of the Company.

_____ Course Supervisor

Date August 10, 1939

_____ Plant Manager

Fig. 2– A Certificate, as an Evidence of Achievement, Is Given after Completion of the Formal Theoretical Study of Arc Welding and Welding Symbols. This Elementary Phase of Study Is Usually Finished Soon After the Student Starts His Simplest Producton Welding Jobs

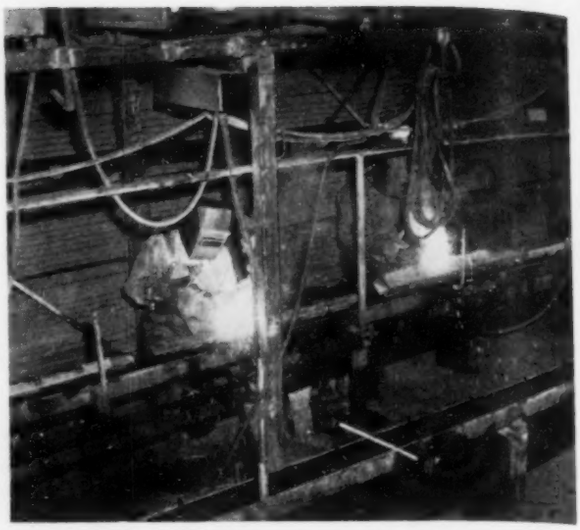


Fig. 3—The Student Welder's First Production Job Is That of Welding Box Sections Which Are Mechanically Set Up, Manually Tacked, Cut to Shape and Pass in Front of the Operator at a Controlled Rate of Speed

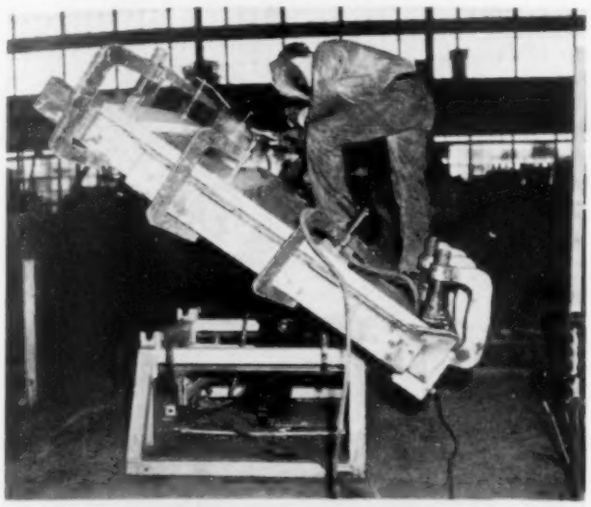
first demonstrated by the instructor and then the student tries his hand at it. The next step is to lay a bead of weld metal in a straight line on a flat plate; and following that comes the process of stopping a bead, changing electrodes and starting the bead again by tying it in smoothly and soundly to the first deposit. The student is taught from the very beginning to burn his electrodes down to a $1^1/_2$-inch butt which he deposits in a small compartment in his electrode stock pot and later returns to the stockroom when he checks out another supply of electrodes. The idea of complete use of electrodes and checking in of the butts in the interest of economy, safety and good craftsmanship is a part of the first day's training.

The theoretical part of the student's training also is begun the first day. At some time during the day the instructor gives the student his copy of the textbook used by the Company and a supplementary sheet with a questionnaire covering both the first lesson in the book and the supplementary lesson sheet. The supplementary sheet, a part of which is shown in Fig. 1, is designed to start the student in his welding experience with the consciousness of welding directions presented as symbols on a blueprint. The reading of the textbook and answering of the questions on the questionnaire for each lesson is done by the student at home or at the plant, and the questionnaire papers are corrected by the instructor and handed back to the student as fast as the student desires to turn them in. At least one a week is required by the instructor under normal circumstances. The content of these will be discussed briefly later.

Six to eight weeks, depending on the student, are spent in practice welding under the close supervision of the Welding Instructor. After he can strike and hold an arc and lay a neat sound bead with one or more breaks and starts in it, the student begins to learn the art of tack welding pieces and welding them soundly together. The butt joint and the positioned fillet welds come first. Proper arc length, position of electrode, and manipulation of the arc are demonstrated by the instructor and then practiced until mastered by the student. Welds which have been deposited are carefully slagged, brushed, examined and criticized. The effect of porosity, under cut, overlap and excess or lack of heat are demonstrated first by the pointing out of their defects and then by actually breaking the welds and allowing the students to see what various flaws actually do to a welded joint.

The more difficult welds follow as soon as the student is

Fig. 4—After Months of Practice on Simpler Jobs, the Student Is Teamed with an Experienced Man on Such a Job as This, Where He Expands His Experience and Adds to His Skill



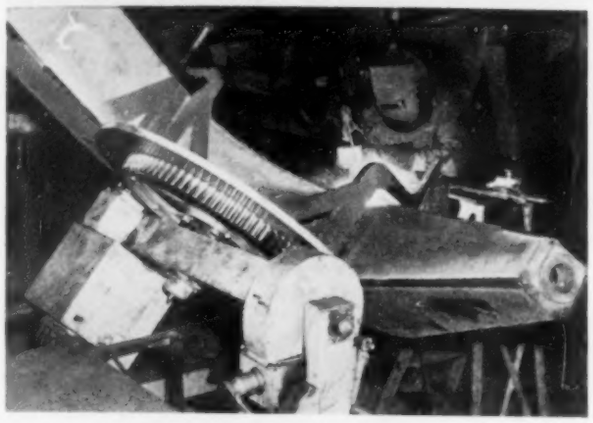


Fig. 5—A Trained Craftsman Is Required to Set Up and Weld Structures Such as This One Into the Large Structure in the Background. Such Training Must Be Acquired on the Job, Over a Period of Time

skilful enough to undertake them. Multi-pass positioned fillet welds acquaint the beginner with the effects of accumulated heat, the need for cleaning of each pass, how much metal can be deposited in one pass with certain sized electrodes, and how to get complete fusion, penetration and desirable appearance.

Horizontal fillet welds are next practiced, with frequent breaking of the specimen welds to demonstrate need for proper manipulation to get good fusion on the perpendicular leg of the weld.

Next in succession are semi-vertical and vertical welds built from the bottom up in one, two or more passes; or down in many passes. Horizontal butt welds, overhead butt and fillet welds, and chamfered welds in all positions are successively studied in detail and each student's individual aptitude and dexterity are developed as he comes to each of the more complex problems. The control of size of each type is learned as a matter of course.

Almost all of this practice welding is done on small sections of plate cut for the purpose, although some of the more advanced students sometimes can weld some of the more simple joints on an order of factory tote bins or some similar factory equipment under the close supervision of their instructor.

The different types of electrodes commonly used in the shop for their specialized purpose such as the all-position electrode, the vertical and overhead electrode, the one adapted to down hand fillet and flat welds and the characteristics of each under different conditions are learned from hours of experience during this practice period.

During the six to eight weeks of practice in the manual learning of welding and extending for four to six weeks after he begins welding on production items the student is studying the theoretical side of his work. The subject matter covers the theory of the welding machine, general terms and names associated with welding, the mechanics of depositing metal by means of an electrode and arc, strength of welds and weld metal, bare electrodes and coated electrodes. All of this general theory is correlated with the manual welding practice first by the Welding Instructor's personal contact with the student and next by the supplementary sheets and questionnaire on the lessons.

Some of the later lessons (there are forty questionnaires and three major examinations over sections of the course) are devoted to the use of special welding electrodes such as hardfacing, special high tensile welding electrodes and procedures and the welding of special metals. This phase of the course is quite theoretical but forms a basis for the special work which some of the welders later do, and serves to widen the student's knowledge of the possibilities of his craft.

The last eight lessons of the formal text study course are devoted entirely to the description and teaching of the system of welding symbols which conveys the specifications for each weld to the operator. The first lesson on symbols discusses "Arc Welding Symbols and Their Purpose;" the second and third explain the arrow base line, location, size and cross-sectional view showing the types of welds; the fourth is devoted to symbols showing the position in which the weld shown is to be deposited and the number of passes to be used; the fifth covers special classes of welds; and the sixth, seventh and eighth present the remaining portion of the symbol system which specifies the size of electrode, type of electrode and machine setting for each pass of the weld. A final examination covers the eight welding symbol lessons, and completes the course. A certificate, Fig. 2, is presented to the student upon the satisfactory completion of the theoretical part of the course. He has been welding on the simplest production work in the shop for from one to two months by the time he finishes his course on arc welding and welding symbols as a rule.

The progression from the manual practice stage in the instruction department to the first production job in the shop is an important one. The regular procedure is to go from practice welding to the welding of a box section consisting of two angles welded corner-to-corner as they pass by the operator on a conveyor, Fig. 3, which travels at a controlled rate of speed.

Since the box sections constitute one of the major structural members in LeTourneau equipment, they are set up mechanically and tack welded manually, are cut to shape before welding, and are welded in sufficient numbers to maintain a full-time job for several new welding operators. The welding is simple, yet has the variety incident to the change in size of beam, thickness of wall and length of piece.

The student welder meets several new factors when he goes from the instructional department to the regular welding of box sections, and for that reason is given close personal attention for a few days by one of the five shop instructors whose function is to establish new men in the various welding departments on jobs as they change or new problems arise. The transition from a student welder, accustomed to close personal supervision by the Welding Instructor, to a regular welder under a different shop foreman who cannot devote as much personal attention to him is made somewhat easier by the departmental welding instructor. The experience of having his work

examined by an inspector is sometimes upsetting to the new welding operator. Also, as a production welder, the new man is initiated into the experience of working for a bonus, and of following specified procedures. The departmental foreman and the departmental welding instructor guide and counsel the new operator in these problems.

After three to four months of welding in the box beam department the operator is usually placed in a department in which various small structures are fabricated. An experienced man sets up the structures in fixtures and tack welds them together, and the new man welds them. Small brackets, sheave housings, gears, etc., constitute the work—almost every one is welded in a special fixture for the easiest handling and most favorable positioning, and every weld is specified completely on the blueprint. Most of the welds are deposited as flat welds or positioned fillets. The work provides a greater variety of welding than box beams, and another departmental welding instructor carefully tutors the operator in the new situations which he has to meet.

After four to six months of experience in the Small Parts welding department, the operator is usually sufficiently skilled to be placed in one of several departments which fabricate the main structures which are finally brought together in the assembly department. As a welding operator in these departments he is usually teamed with an experienced man in the department. Together they set up the structure in a fixture such as is shown in Fig. 4, and then weld it in the same fixture or a special welding fixture which allows for more favorable positioning. This type of work further widens the experience of the operator, by giving him a wider variety of welding problems. The depositing of more welds in the horizontal fillet position and a few in the semi-vertical or vertical position, the greater size of the structures and more welding per unit completed, more complex joints and a larger variety of sizes and types of electrodes used are some of the requirements which develop additional skill in the welding operator's craftsmanship. At that stage of training the learning welder really begins to become proficient in the use of the arc as a universal tool for fabrication.

After several months of experience in one or several of these structure fabricating departments the average operator in training has acquired the knowledge and skill which enable him to do most of the ordinary welding which is encountered in the factory. With a short period of time allowed for his learning the special fixtures for the job, studying the prints and practicing on the job, he can usually perform the processes in the normal time required by an average operator and with a degree of skill which meets the standards of quality required by the job. Real proficiency and the ability to do such jobs as the one shown in Fig. 5 take more time.

At the end of from twenty-four to thirty months after the man was hired to learn to weld he has usually become sufficiently trained in the LeTourneau methods of doing things, and has become sufficiently adept at performing his welding tasks that his individual preferences, abilities and inclinations tend to direct him toward the place in the organization for which he seems best fitted. A skilled departmental instructor is always available to help him solve his problems and become a better craftsman. The elementary training period is over and the man has become a member of the organization with a specialized function which lies within his own power to develop and expand with each year of service, practice and study.

Design and Profitable Manufacture Based on Arc-Welded Fabrication and Assembly*

THE business of the company with which the writer is associated is the manufacture of industrial tractors, trucks and trailers. These products are made largely from metal and production involves the machining of castings and bar stock, the cutting and forming of rolled sections, and finally the assembly of the parts into the complete unit.

Design for *strength* is the prime requisite. Utility places definite limitations on size. Strength cannot be attained by increasing bulk. The units must be sufficiently compact to work in the confines of aisles allowed for hand trucking. At the same time, they must be capable of towing loads up to 70 tons and lifting and carrying loads in excess of 10 tons. It has been authoritatively stated that no mobile unit of comparable size in use today would stand up under the use and abuse that is accepted as commonplace in the daily duty of an industrial tractor or truck.

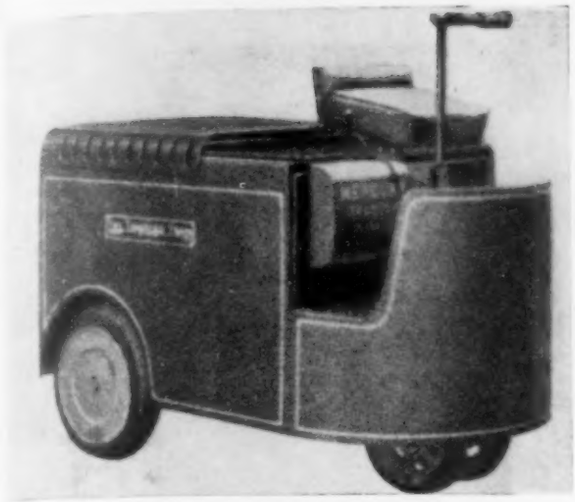
Design for *economical production* is second in importance only to design for strength. In common with many others engaged in fabricating metals into the tools of industry and commerce, we must struggle with the problem of designing and producing a range of types and sizes, each of which will be produced in a strictly limited quantity. Profitable operations in this field are largely dependent on creating designs that can be made from readily available materials (such as rolled sections and shapes) and fabricated and assembled with standard machine tools and auxiliary equipment.

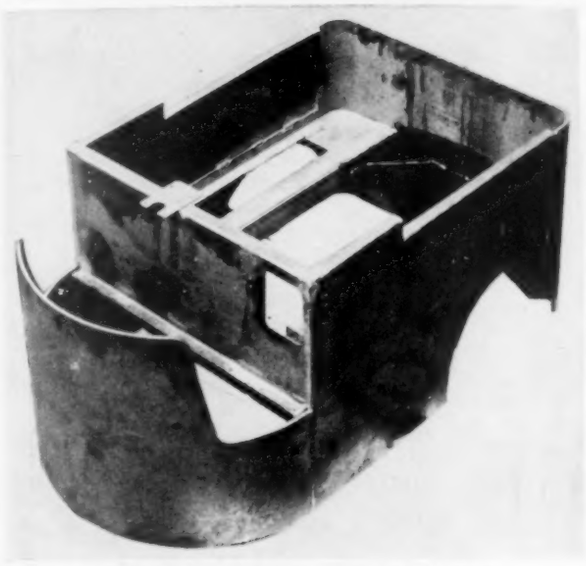
In order to deal most advantageously with our problems, we have tried to be alert to the possibilities of new processes and equipment that might be adaptable to our needs. Some ten years ago, we purchased our first arc welder. It was installed primarily to perform a simple operation of assembling a pipe rack. In due course, it was assigned other and comparable tasks. Shortly, a second machine was added to our facilities, and then a third and a fourth.

So well did these machines fit into our production requirements that the engineering department began, in a modest way, to *design* minor assemblies for welding fabrication. Starting in this manner, the program gradually gathered momentum. More and more parts and sub-assemblies changed from castings and bolted and riveted designs to all welded construction.

Eventually the time came when it was deemed desirable and opportune to completely redesign our line. Profiting by the experience and knowledge already at hand, we determined to explore the possibilities of welding to the limit before embarking upon a new engineering program. This exhaustive study led to just one con-

* Data and illustrations from a study submitted to the James F. Lincoln Arc Welding Foundation by L. J. Kline, Vice-President and general manager of Mercury Manufacturing Co., Chicago, Illinois, in a recent program. In its current $200,000 Industrial Progress Program, which closes June 1, 1942, the Foundation is offering 458 awards from $100 to $13,700, for reports of advances and improvements made by application of arc welding in design, manufacture, fabrication, construction and maintenance.





Arc-Welded Steel Frame Assembly of Tractor

clusion, that by creating our designs for the full utilization of arc welding as a major process, avoiding castings and bolted assembly wherever possible, we could: (1) attain maximum strength with minimum bulk; (2) have the greatest advantage in the use of readily available, low cost, raw materials; (3) pre-fabricate and assemble a variety of products with standard machine-shop equipment; (4) at the lowest cost for both raw materials and labor.

A specific example will perhaps best indicate the major advantages which follow a deliberate policy of designing for "welded" production.

Early in 1937, it was decided to bring out a new model heavy-duty gas industrial tractor to replace an existing unit. Welded fabrication was a basic design feature.

The main frame assembly (see Fig. 1) employed for the tractor is the major feature selected to present the manner in which welding is employed in its construction. There are just 26 separable parts in the complete frame and these parts are all made from *standard* rolled plates and shapes. Each part has been designed into the completed structure to add strength without increasing bulk and at the same time meet its utility function. For instance, the front bumper is the chief strength member at the forward juncture of the side plates as well as the guard for the radiator. Similarly, the rear wheel fenders not only reinforce the longitudinal members but also place added weight where needed for traction, plus their utility duty of protecting the driver from road soil thrown up by drive wheels. The step plates not only make for convenient access to seat but also tie in the front and rear wheel fenders for strength and line.

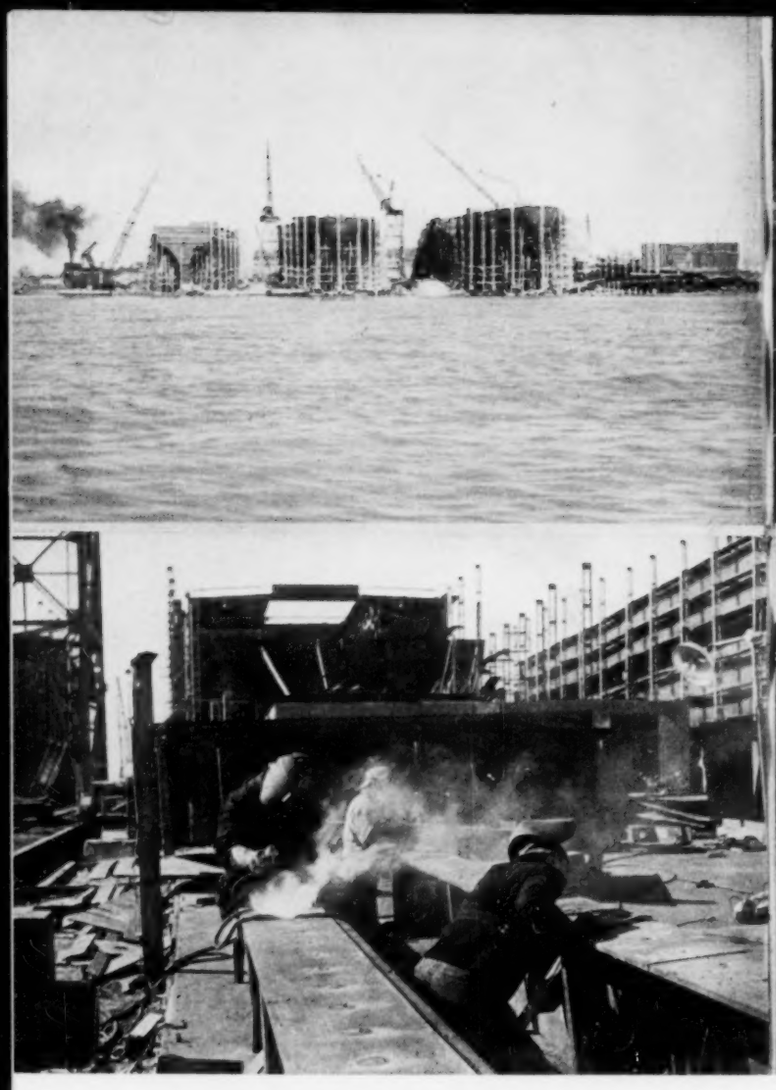
How well the requirements of "readily available material" and "production with standard machine-shop equipment" are observed is shown by the following tabulation.

Bill of Material for Tractor Frame

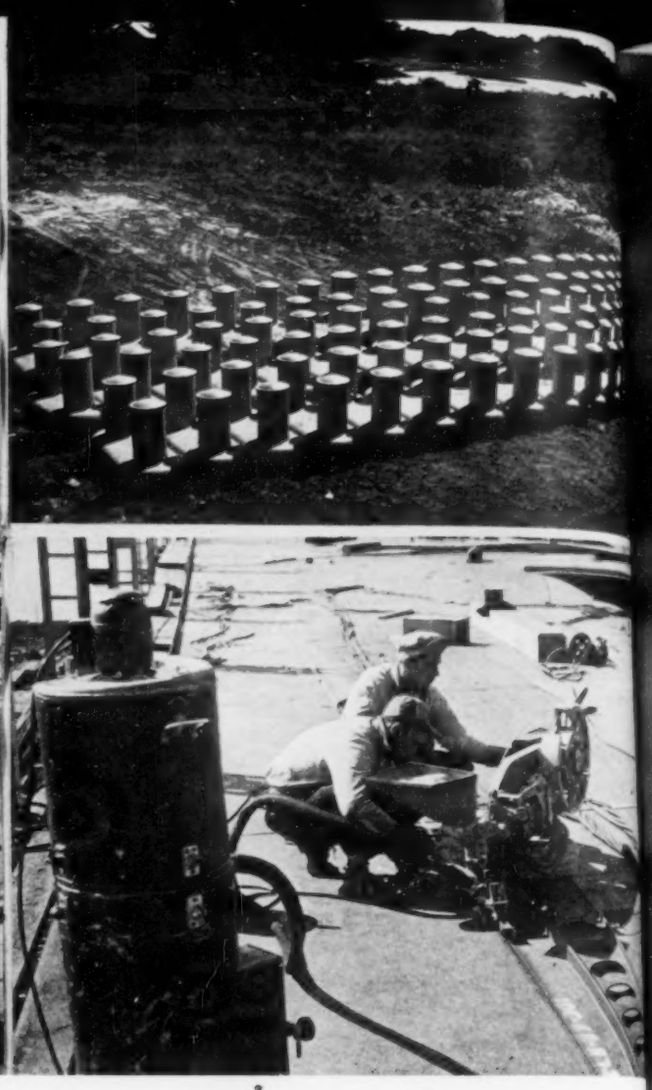
Part	Reqd.	Raw Material	Operations to Prepare for Assembly
Front bumper	1	3/8-in. steel plate	Shear, flame cut corners, brake and perforate
Side plate R.H.	1	3/8-in. steel plate	Shear, brake, flame cut and drill
Side plate L.H.	1	3/8-in. steel plate	Shear, brake, flame cut and drill
Rear bumper	1	1-in. steel plate	Shear
Rear fender	2	1-in. steel plate	Shear, flame cut corners and roll
Front fender L.H.	1	1/4-in. steel plate	Shear, flame cut corner and roll
Front fender R.H.	1	1/4-in. steel plate	Shear, flame cut corner and roll
Rear top gusset	1	1/4-in. 4 way plate	Shear
Cross member (front spring front bracket)	1	4 x 3 x 3/8 angle	Cut to length, shear corners and drill
Cross member (front spring rear bracket)	1	4 x 3 x 3/8 angle	Cut to length and drill
Cross member (rear spring front bracket)	1	7 x 4 x 3/8 angle	Cut to length, flame cut and drill
Cross member (rear spring rear bracket)	1	7 x 4 x 3/8 angle	Cut to length and drill
Front gusset and radiator support	1	3/8 x 3 1/4 flat rolled steel	Shear and drill
Stiffeners	2	5/16 x 1 1/2 flat rooled steel	Cut to length and brake
Steering bracket support	1	3/8 x 6 flat rolled steel	Shear and drill
Trim plate L.H.	1	No. 12 ga. x 3 band steel	Shear and notch
Step plate L.H.	1	3/16 4-way plate	Shear and brake
Step plate R.H.	1	3/16 4-way plate	Shear and brake
Rear fender cover	2	1/8 x 8 sheet steel	Shear
Engine support front	1	2 x 2 x 1/2 angle	Cut to length and drill
Engine arm block R.H.	1	1/2 x 2 1/2 flat rolled steel	Cut to length and drill
Engine arm block L.H.	1	2 1/2 x 3 flat rolled steel	Cut to length and drill

The decidedly beneficial results achieved by designing for "welded" production are strikingly emphasized by contrasting the frame of the tractor as formerly built with the frame of the unit in welded steel. The following condensed tabulation is pertinent to this end. Arc-welded steel employs just 26 parts as contrasted with 94 parts (including bolts and rivets); has an increased beam strength of 50%; has an increase of 200% in rigidity and resistance to side distortion; is produced at a per pound cost (labor and material) of 22% *less;* presents a more pleasing and finished appearance, attributable to all-welded frame design. Appearance today has sales appeal of first importance even for industrial equipment.

It was stated at the outset that this company has in recent years completely redesigned its line. A feature of this engineering program makes the most comprehensive use of "arc welding" as a major manufacturing process.



(Top) Stern of Vessels from River
(Bottom) Welding on Number 2 Platten



(Top) Bitts for C-3 Cargo Vessels
(Bottom) Unionmelt Machine in Operation

The First All-Welded Cargo Ship Built Under Maritime Commission Specifications*

By Alfred C. Leigh†

THE Ingalls Iron Works Company, parent of the Ingalls Shipbuilding Corporation, is located in Birmingham, Alabama, and at the present time, the executive offices of both firms are located there.

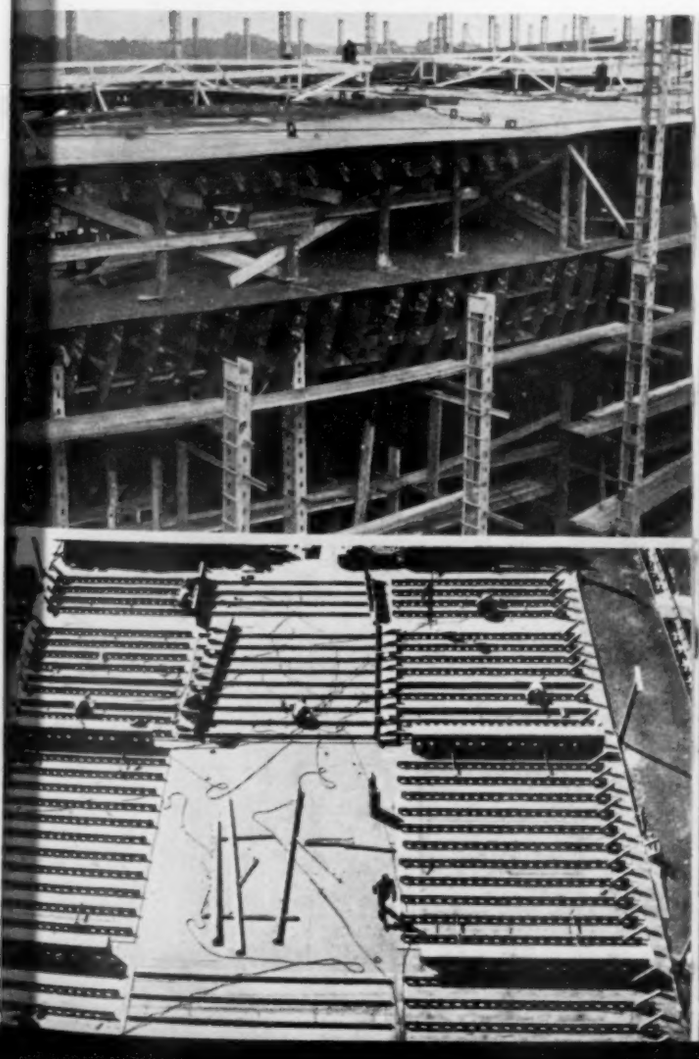
Prior to the forming of the Ingalls Shipbuilding Corporation, the Ingalls Iron Works Company had been active for approximately ten years in the building of small all-welded vessels of various descriptions. The majority of these smaller crafts was for use on the inland rivers, the building yards being located at Decatur on the Tennessee River and at Chicasaw, Alabama, about six miles from Mobile. The extensive experience which the Ingalls Iron Works Company had in welded construction due to these activities and also due to the all-welded construction of tanks and structural work, was the basis upon which the Maritime Commission was approached in order that we be permitted to bid on the building of ships for the Maritime Commission's program on an all-welded basis. You will recall that the original contract issued by the Maritime Commission was for the building of the C-2 type cargo vessel. At the time bids were requested by the Maritime Commission for these ships, the Maritime Commission on being approached informed us that they would accept a bid for all-welded construction of the C-2 type ships, if, at the time of presenting the bid our conception of an all-welded design be presented. The time limit was not sufficient for the preparation of designs so we did not bid on the construction of this type of ship. The specifications for the C-3 cargo vessels were so written to permit the yards, who were successful in securing contracts, to use their own judgment as to the extent of welding they desired to use in the construction of the ships with the limiting factor that all details of construction should meet with

* Presented at January 14, 1941 Meeting, New York Section, A. W. S.
† Naval Architect and Marine Engineer, Ingalls Shipbldg. Corp., New York.

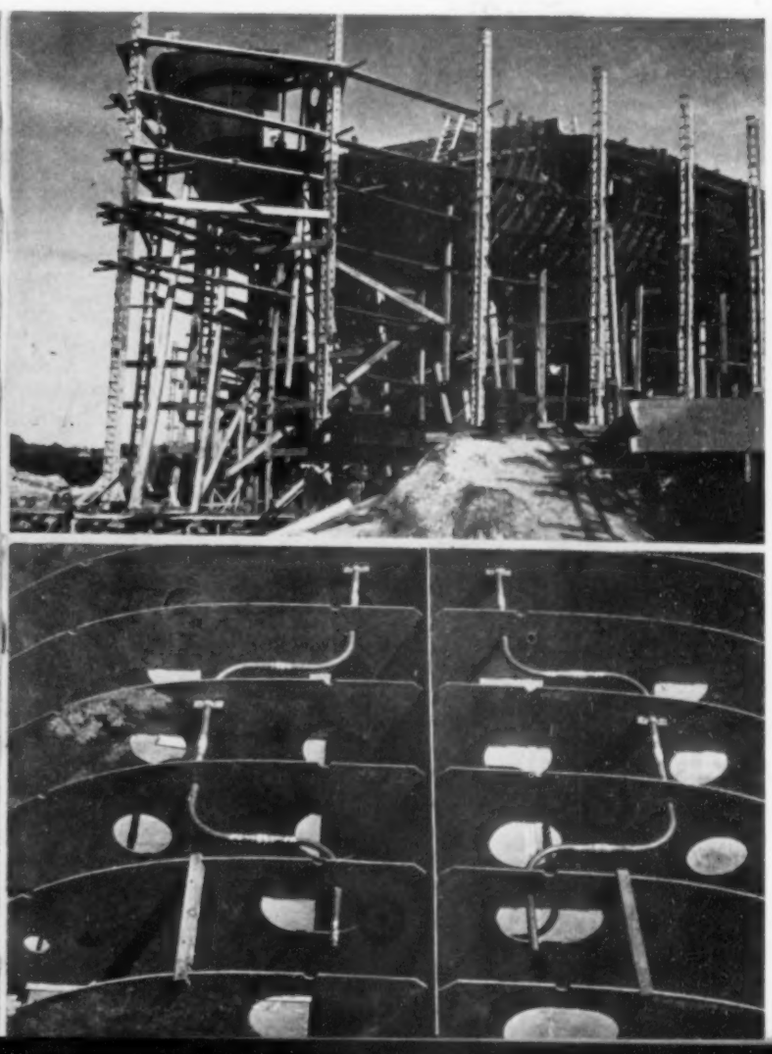
the approval of the Maritime Commission. Upon this basis we prepared our first estimate bidding upon the C-3 type ships and were successful in securing our first contract. At the time of preparing our estimate, our Engineering Staff, under the able direction of Mr. W. R. Guest, Vice-President and general manager of the Ingalls Iron Works Company were preparing preliminary design studies of a shipyard for the construction of welded ships. We subsequently purchased the property where our yard is located at Pascagoula, Miss. In answer to the frequent question, "Where is Pascagoula located?" it should be stated that Pascagoula is located on the Gulf Coast, approximately 44 miles west of Mobile, Alabama, and 100 miles east of New Orleans, La. Pascagoula has had an interesting background in shipbuilding activity. Due to its natural resources, wooden ships were constructed in Pascagoula in the early days before the Louisiana Purchase. It is reported that Longfellow wrote his famous poem "The Building of the Ship" at Pascagoula, in fact, the old colonial home occupied by Longfellow still is in good state of preservation and the former Mayor of Pascagoula uses this old home as a homestead. Before the advent of the shipyard, Pascagoula itself was a very small village, yet, is rich in historical associations of the old South. Of course, since the building of our yard at this location Pascagoula has become a very thriving town, almost similar to the boom towns of the old mining days of the West. We, being successful in securing a contract from the Maritime Commission, immediately broke ground for the shipyard which is now a going yard, in fact, if you were to visit this yard it would be noticed that the building ways themselves have all the appearances of having been there for many years. This yard was designed, having in mind the use of facilities for fabrication which the Ingalls Iron Works Company possessed at Birmingham, Alabama, the Ingalls Iron Works Company having enjoyed for a number of years a top ranking position in the independent fabrication of structural steel in the United States. It was natural that we would not require at our building yard the duplication of the facilities for fabrication which we had in Birmingham, therefore, an inspection of our yard without a knowledge of the background of the organization would create immediate bewilderment on seeing the small fabricating facilities at the yard, compared with the shipbuilding work on the ways themselves. It appears to be almost a miracle. I believe that all-welded construction lends itself to the pre-fabrication of materials at a location remote from the shipyard, whereas riveted construction does not, because of the well-known inaccuracies associated with rivet holes, to remedy which much work requires to be done at the shipyard and on board the ship involving the use of punches, drills and reamers at the yard.

Prior to the building of the yard and the necessary shops, we sought the advice of the experienced shipbuilders throughout the United States. I wish to remark that all the large building yards where ships had been built with a combination of riveting and welding, received our delegation with open arms and were very cooperative in giving us the benefit of their experience. You will recall the papers which have been presented to your SOCIETY surrounding the activities at the Federal Shipbuilding yard and at the Sun Shipbuilding yard. Both of these yards, prior to the advent of welding were

(Top) Hull Number 254 Side Framing
(Bottom) 2nd Deck Assemblies on Number 2 Platten

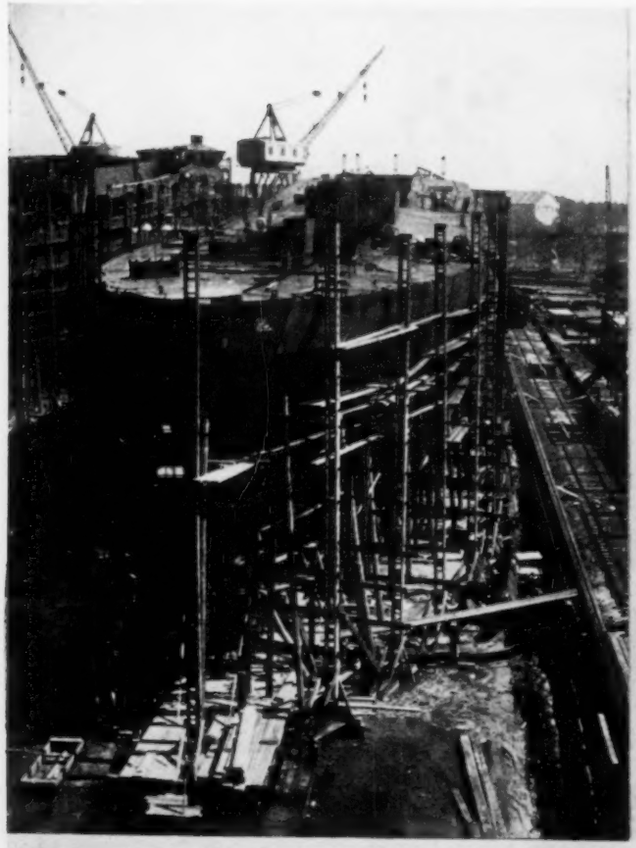


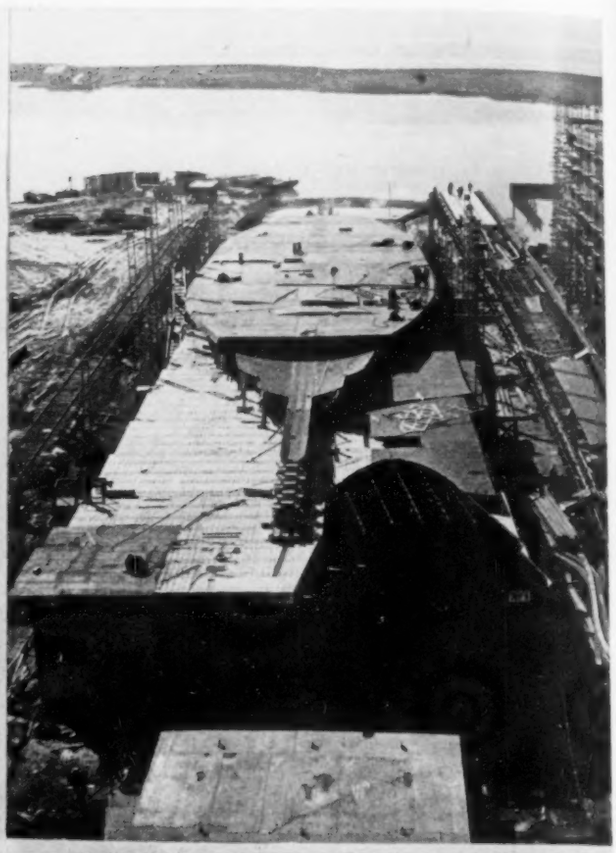
(Top) Hull Number 254 Cruiser Stern Assembly in Place
(Bottom) Inner Bottom Assembly from Head of Ways

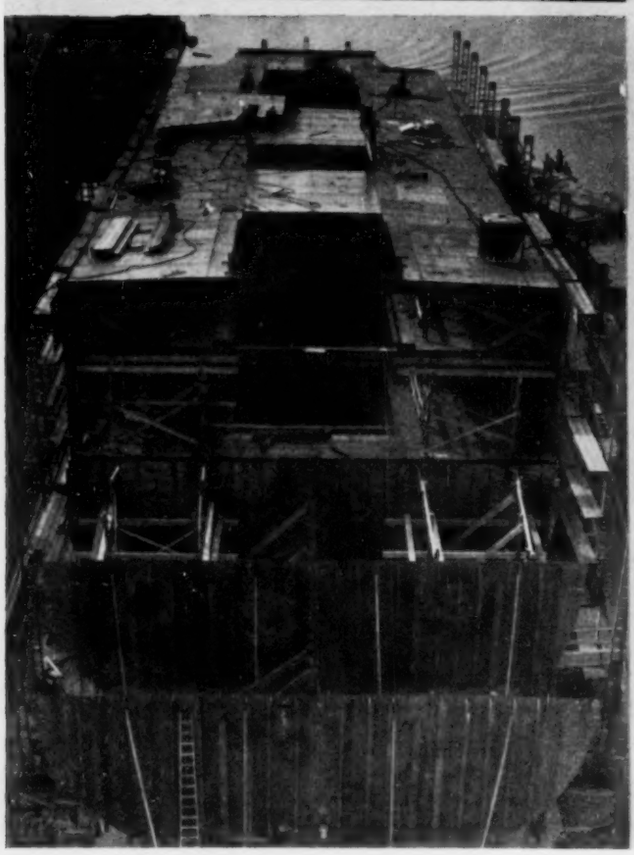


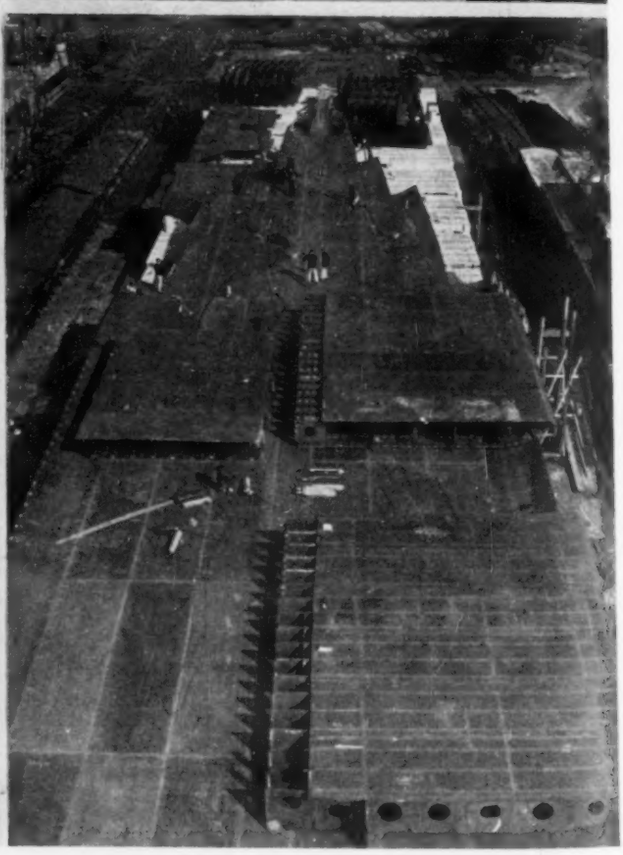
Hull Number 253 Looking Forward

C-3 Cargo Vessel U.S.M.C. Hull Number 66









Hull Number 254 Group 4 Assemblies

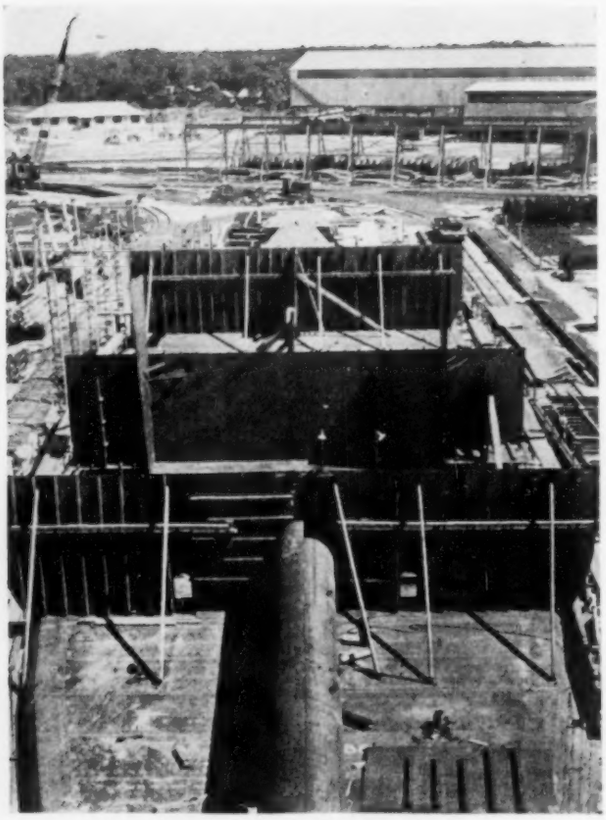
Hull Number 256 Looking Forward

building riveted ships, thus, these yards have the full equipment required for the building of riveted ships. It is naturally the desire of these yards to utilize to the best advantage the facilities that they have for riveted construction; also, old employees of these yards must be employed. It is our firm belief that if either of these major building yards were to start out to build a new yard such as ours, they would build and outfit the yards for the production of all-welded craft, in fact, certain executives of these yards have so expressed themselves.

In order to secure the full benefits of welded construction it is necessary to do a considerable amount of pre-assembled work. This pre-assembled work is limited in size only to the capacity of the cranes at the building ways. Having this in mind, our gantry cranes at the building ways are of 35-ton capacity and the pre-assembled sections of various portions of the ships are built up to satisfy the limitations of these cranes. At present we are building two additional ways at our yard which will give us a total of six building ways. We are increasing the capacity of our cranes on these two ways to 50-tons. This is not done with the idea of increasing the size of the pre-assembled sections, but is for the benefit of handling large units of machinery in an assembled condition rather than handling the machinery in knocked down sections. The method we employ to utilize the fabricating facilities at Birmingham is to pre-fabricate all frames and flat plating work, limiting the pre-fabrication work done at the yard at Pascagoula to the formed plates and furnace work. Birmingham is located approximately 325 miles from Pascagoula. There are three methods of transporting the fabricated materials from Birmingham to the yard. Trucks leaving our plants in Birmingham in the evening will arrive at the yard the next morning with their load. The Birmingham plant is located on the line of the L & N Railroad and our Pascagoula yard likewise. Pre-fabricated materials can, therefore, be shipped overnight from Birmingham to Pascagoula. Birmingham Port, located on the Warrior River, is approximately 15 miles from the Birmingham plant. Barge lines utilizing the Warrior River permits the loading of materials at Birmingham Port and the subsequent delivery by water to Pascagoula. For items of machinery, both main and auxiliary, water transportation can be utilized by coastwise to Mobile, and/or, New Orleans, and shipment can be made by local carriers to the yard either by truck, rail or water. You have probably had the opportunity of reading Mr. Arnott's paper presented to the Naval Architect's Society in 1935, just a few years ago. For those who have not followed the transition of riveted shipbuilding to welded construction, I wish to state that I consider Mr. Arnott and his associates of the American Bureau the prime factors in the adoption of all-welded construction in the United States. In Mr. Arnott's paper he gave the history of welded construction which had taken place in the few years prior to the presenting of this paper. It is astonishing for one to realize the rapid growth of welded construction over a very short period of time. I well remember a very few years ago when I was called upon to sell the all-welded crafts which we were building at the yards of the Ingalls Iron Works Company. At that time the men whom we approached, in order to turn down all-welded construction, graciously admitted that the only objection they had to welding was the personal element. Today this has been practically eliminated. To me one of the most astounding developments in the welded ship today is the fact that continuous girth welding is permitted. I am sure that the ship designers among you have spent many a weary hour in the past developing a shift of butts which would meet the approval of the classification societies. This is a lost art today and the shift of butts now is only limited to the joints in the sections which it is desirable to make in order that pre-assembly in the proper handling sizes can be made. Plates of the deck may run athwartship or longitudinal depending upon the best results which may be obtained for pre-assembly. This I believe covers one of the major developments in ship structures due to the welded art.

It is a well known fact that in riveted plate work wherein the seams and butts are riveted either with single, double or multiple lines of riveting which are required, the joint thus made is only good for from 60 to 75% of the value of the parent plate. In other words, the joint must be considered at 100% plus factor of safety, the parent plate must naturally be made of greater section than would actually be required in order that the continuity of strength throughout the structure can be had, the joint being the weakest link. In welded joints where butt welding is employed, we find, depending upon the purity of the weld, that the welded joint will develop from 90 to 100% of the sectional value of the parent plate. Many articles have been written on welded construction and one of the main points covered in all of these articles indicates a great saving in weight which can accrue from welded construction. You must all agree that the immense areas of plating which are used in ship construction are the major weight elements in the structure. It appears obvious that since the welded joints of plating will develop practically the same strength as the parent plate the plating thickness now required by Rules and Regulations of various societies could safely be reduced for welded construction. The infinitesimal savings in thickness of plating due to the large areas of plating used in ship's structure would, no doubt, result in a great weight saving development for welded ships and since this is the ultimate end we are all striving to arrive at, I make this suggestion based on the known fact that present Rules and Regulations for plating thicknesses are based upon ships built of riveted construction. There is, of course, other factors which limit the plating thicknesses other than the riveted or welded joint, therefore, in making the above statement it is known that we must satisfy the practical requirements as well as the theoretical.

Keel laying will, in a very short time be also a lost term in the building of ships, for keel laying, as such, on the welded ship does not exist. The plan we are at present following in lieu of keel laying is to lay the entire flat bottom of the ship. The butts of the plating fall horizontally in a continuous line athwartship and the seams which, of course, are in a line, are butted, no laps of plating being used throughout the entire hull plating. The flat bottom plates after being tacked into position are then lightly welded with a seal bead overhead. The plates are V'd on the inside surface for automatic Unionmelt method of welding. The Unionmelt weld is applied so rapidly that the shrinkage or distortion of these plates is practically nil. Due to this, pre-fabricated sections of the inner bottom can be laid on the plating in their proper locations for down-hand manual welding. The floors or inner bottom frames are fabricated completely in our Birmingham plant and the inner bottom plating is cut to size and edges dressed. When these pre-fabricated floors arrive at the yard they are placed upon plattens. The plattens consist of large areas of flat surface usually made of steel plates welded together and form the base upon which the pre-fabricated pieces are assembled. For the midship section of the vessel, the inner bottom pre-assembled sections are assembled in



Hull Number 255 Looking Forward

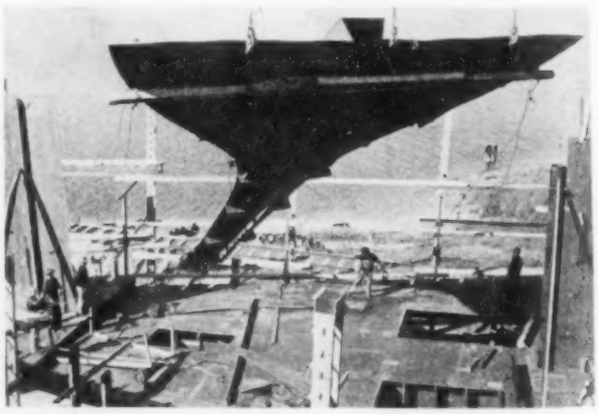
half ship widths. These sections are approximately 25 feet lengthwise of the vessel and half-width of the vessel in the other dimension. The floors or inner bottom frames are welded to the inner bottom plating in the down-hand position or in other words, upside down. After the frames are welded in the inner bottom plating, the inner bottom plating seams or butts are then welded automatically by Unionmelt method and the sections are lifted into their proper position on the vessel at the shipways. These sections are tacked together and either hand welded or automatically welded in accordance with the demands of the situation. All of the deck plating is also pre-assembled into sections similar to the inner bottom sections. The bow and stern are also built up of pre-assembled sections. In general, I believe, this explains the methods employed. There are so many hundreds of different sections that the limitations of this paper would not permit an itemized description of the methods of handling these individual cases.

To me, we had a very interesting occurrence during the trials prior to the delivery of our first all-welded cargo vessel. Inspectors of the Trial Board had been sent from Washington with instructions to have the ship in readiness for the official trial. The United States Navy having purchased from the United States Maritime Commission our first ship sent their trial board to be present at the trials. They were only to be on the ship a few hours, at which time we would be called upon to put the ship through various tests. Due to the short length of time that the trial board of the Navy could be present, the ship of necessity was required to be ready when the trial board came aboard the ship. When the Director of the Trial Board of the Maritime Commission came on board, after having checked the drafts of the ship, he was very much incensed that the ship was not down to proper draft and immediately desired to know why the ship was not properly ballasted for the trials. After being informed that the ship was ballasted in accordance with the requirements, and all tanks having been checked to prove that this was the case, the only explanation as to why the ship was not down to the proper draft was due to the immense savings in weight which was the result of her all-welded construction. This all-welded ship has an absolutely smooth surface on her hull due to butt welding of the longitudinal seams and butt welding of the girth seams or butts of the plating. This presents an unusual phenomenon to the eye of anyone accustomed to laps of plates which is usual in riveted construction and due to the smooth bottoms and sides it is our contention that these ships will have more speed per horsepower than other ships built utilizing riveted construction. This, naturally, is not only due to projecting edges of lapped plates, presenting friction in the water, but also the thousands of rivet heads which do likewise. Unfortunately our contract does not call for sea trials wherein the marked-mile speed tests would be made, but by careful reckoning we are able to calculate that this ship on her trial run at normal designed horsepower was traveling at 20.1 knots, which I believe is the record for the C-3 type of ship.

For the benefit of those who would be interested to know the length of time required to build our yard and build the first all-welded vessel I give you the following dates: We broke ground on the property where our yard now is located February 20, 1939. On May 12, 1939, the Main Fabricating Shop and Mold Loft were completed and ready for use. Our buildings were ready and fully equipped for operation on July 10, 1939. The first templates were ready June 30, 1939. Building Ways Nos. 1 and 2 were ready July 1, 1939. Way No. 3 was completed on August 1, 1939, and No. 4, which was a later addition to the yard, was completed December 15, 1939.

It was our original intention to build only 3 ways, but a subsequent contract from the Maritime Commission indicated the necessity of a fourth way. The bottom plating for the first ship was laid August 15, 1939, and delivery was made November 15, 1940, or a period of 15 months being required from time of laying bottom plating to completion of our first vessel. This delivery was prior to contracted delivery and if it were not due to the fact that numerous changes in the ships structure were required which were changes under our original contract, we could have anticipated the delivery of this first ship.

It may be interesting for you to know that we are negotiating with the United States Navy for the build-



Hull Number 255 Erecting After Peak Bulkhead

ing of net layers. These net layers are approximately 465 ft. in length and 63 ft. beam. It is obvious that since our yard is built only for all-welded construction it was necessary to secure the permission of the Navy to build these vessels of all-welded construction and I am pleased to inform you that the Navy has agreed.

Why the Increasing Use of Welding in Structural Frames?*

By Van Rensselaer P. Saxe†

TODAY a large number of engineers are beginning to be interested in welding as applied to structures. It is mainly through the efforts of electrical welding equipment engineers, construction company engineers and research men that in the past ten years welded structures have made great advances. The constantly widening field for uses of welding convinces me that it is fast leaving the stage of infancy to become a hard working young man.

Welding has developed so many types of use it has reached a point where men are compelled to specialize on study of the type of use in which they are interested.

The subject of applied welding is entirely too wide in its uses for any individual to become familiar with all of its ramifications. You have only to look at the many chapters, each devoted to a different use, of the handbook of the AMERICAN WELDING SOCIETY, to understand this. This paper will only cover that portion of welding as applied to its use in building structures.

For some strange reason there has been less progress of the use of welding in building structures, than in any of the other fields in which it has so rapidly displaced other means of fabricated assembly. In fact, so small is the proportion of welded structures to other types of assembled structures that we might almost say this field and this use for welding is practically untouched and is wide open to those with the foresight to take advantage of the possibilities.

The History of Steel in Structural Work

Now, why should this be the case, and it has been the same story in the development of each new material which has come into the structural field. Take structural steel as an example. There are still living among the older engineers, those who can remember all the harsh statements made about steel at the time it was being talked up as a substitute for Wrought Iron. I can still remember one of my professors at R. P. I. telling me that he worked three years doing nothing but making test pulls of steel samples until after having made about 50,000 tests for some engineering board of that day, it was decided that in spite of what was said, the steel proved to be uniform enough to get its adoption for the purpose in hand.

Well, do we think that way about steel today or do you think it is possible to get some one to design a wrought iron frame? Ask some engineer to do it and see what he will answer.

The History of Reinforced Concrete

Try thinking about the rapid advances of that other material which was not so long ago, that most of you have no trouble in remembering its tremendous strides to usefulness, namely reinforced concrete. My earliest recollection of the use of that material combination was the Mineola Court House. The County Supervisor who awarded the contracts for this building to be constructed of reinforced concrete by Ernest Ransome, was the subject of so much criticism on the part of steel fabricators and builders of that day, that he nearly lost his job. But being an intelligent citizen and having put a good cost saving in the county treasury by the switch from steel to reinforced concrete he stuck to his guns and the Mineola Court House of reinforced concrete, the first large reinforced concrete building in this county, still stands a monument to one man's insistance that this new material be used.

I can still remember the first reinforced concrete building on which I worked as one of the hands. I firmly believe that every man on that job including myself was afraid of it. And this in spite of the fact that we knew it had been for years successfully used in Europe.

This story of steel and of reinforced concrete is discussed because most of us in our business are familiar with the story.

Now both of these items had plenty of opposition, engineers, fabricators, and every one else, but year after year each continued its steady progress, until today each is a standard accepted material of construction and what do you think about the engineer today who (and there still are some) states he is afraid of reinforced concrete?

By this time you are probably wondering what these materials have to do with a paper on welding. Well, each in its day was the forerunner of a violent revolution in construction materials and methods, but in spite of hell and high water they forged to the front, until today they stand on top.

Why was this, that in spite of early failures of steel and reinforced concrete, men continued to use and improve them, so that as they learned to control them, these materials continued the upward march?

The reason was purely economic, for here were materials which for each dollar spent on them, produced more value than any other materials which preceded them and to date they hold the ladder top, because no new material has developed to replace them. They will hold this position only so long as that dollar value continues to exist. The minute some other material or combination of materials shows more value for the dollar paid, then out these two go.

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* Presented at February 21st Meeting, Western New York Section, A.W.S.
† Consulting Engineer, Buffalo, N. Y.

The History of Structural Welding

The story of structural welding progress is most remarkably like that of reinforced concrete. About twenty years ago we heard vague rumors that such an idea had been tried. Then step by step through the engineering journals we read or heard from other sources a little more about it, until one day some wild engineer and a steel fabricating company had the guts to build a real building, then we heard the Navy was trying it on battleships and destroyers, the railroads trying it on car building until now it seems that every one is using it.

The ship builders, tank and boiler makers, train manufacturers and nearly every one is running away with it, but the steel fabricator and the structural engineer are still standing, watching the parade. Now, what's the matter with them? Well, they say they are conservative. So were the Tories during the revolution, but the revolution went on to a finish just the same. Certainly the structural engineer who will without hesitation ride in a welded train or ship can lay no claim to being more conservative than the Marine Architect nor can he claim that his structures are subjected to any comparison of stress with those which occur in ship or train operation.

The real truth is we are all creatures of habit, we started using rivets when we were boys and we do not like to change. The steel fabricator has a lot of money invested in riveting equipment and he does not like to see it junked too fast and I do not blame him. He fought reinforced concrete because his steel tonnage was falling off, but that did not stop reinforced concrete. You can't stop the dollar value. Well, the next thing he watched some of the little shaky reinforcing bar suppliers grow into strong companies. Then what did he do, well, he decided he had better join the parade so he set up a bar department. But the big bar companies had grown pretty large and they made the fabricators' bar department hustle, so that even today after years of bar department effort, they still cannot get the bar business that would have been theirs, had they started the bar department when reinforced concrete was a youngster.

Well, what were the older engineers (with a few exceptions) of that early period of reinforced concrete doing? They had pretty much the same attitude as the fabricator. They continued to look down the nose at reinforced concrete, would not take the trouble to learn something about this interloper, until it was almost too late.

Then they woke up to find that a lot of very good clients were giving the designing of their jobs to the young engineers in the bar companies and it was not so long after this that these young men previously employed by the bar companies, set themselves out with a shingle as reinforced concrete experts so the older men never did get this business back, and they gradually dried up, for to make matters more difficult these young men were smart enough to learn the steel framing game too, so they were doubly equipped to do work.

Well, it all simmers down to the same story that economy did the trick, for good buyers insist on the most value for the dollar spent.

Would you not think, with all of this record of something that has happened in our generation, that so far as the use of welding goes, we would profit by this experience and not let welding get out of control of the hands to which it belongs?

Advantages of Welding

Let's see what welding in structural frames can do which no other method of assembly can accomplish.

In a shop set up to do structural welding in the same systematic manner in which they would do riveted work the use of welding reduces fabrication costs.

With a proper set-up, erection of welded work is more economical than riveted work and the cost of field welding is less than the cost of equivalent field riveting.

A welded structural frame can be built with less tonnage steel to carry equivalent loads. The welded frame is a stronger and more rigid construction.

The details of connections are most simple and require much less material than similar riveted or bolted connections.

There is less accident and fire hazard during construction due to lack of falling hot rivets. It greatly simplifies additions and alteration to existing structures.

Last, but not least, it is a silent construction where its use in office, hospital, apartment house and hotel districts is of greatest benefit.

Now, how under the sun can you engineers and fabricators hope to keep anything down on its knees that will accomplish these results? You can't do it any more than the wrought iron fellows kept steel down or the old engineer and steel fabricator kept reinforced concrete down.

Why not grow up with it, instead of letting it grow and get away from you as the bar business did for years? This goes for the structural engineer as well as the fabricator, for it's not only those engineers of bygone days, who could tell you how much work they lost to the bar companies that they as engineers never did get back, simply because they did not think much of reinforced concrete and what's more did not want to know anything about it, until they suddenly discovered reinforced concrete was going into half the structures being built. Then after it was too late and the steel fabricators tried to get on the band wagon, the engineers only to find that the younger men had replaced them and the steel fabricators to find that they had a real fight to get back the bar business they should have had in the first place.

Repeating Old Mistakes

When it comes to welding let us not repeat these mistakes. I say this advisedly, for I regret to say there have been definite signs of a repetition of those old mistakes.

Are the steel fabricators cooperating? I say no.

Are the structural engineers designing welded work of even enough steel tonnage to scratch the surface? Again the answer is no. I cannot understand the reason, unless through lack of study and reading they have insufficient confidence in welding to try it out even gradually, so that they will be equipped to give the architects and owners for whom they work the benefits that are securable from its use. Some well established engineers who can only think in terms or rivets and who seem to feel that a weld is something akin to putty, instead of being a continuous series of microscopic cast particles of steel joining other pieces of steel; better think the matter over, before they get in the same fix as their predecessors about reinforced concrete. Instead of being leaders it seems the engineers are once more being led.

Well, who is using and promoting structural welding for the benefit of general public economy?

Without doubt the ship builders lead the procession, and this covers private as well as Navy owned ships.

Following them are the railroads with a large amount of welded rolling stock. The tank and boiler builders follow.

Bridges, practically none, though in Europe before they started tearing things up, there were around 700 welded bridges. Many of these were railroad bridges.

The Society has a fine specification for welding of bridges, but no one uses it.

Last and least is the building industry, and why! Because except in rare instances which I will take up later, buildings are designed by structural engineers for architects. You can count on your fingers the number of structural engineers who have taken enough interest in welding to use it in the construction of an outstanding building. In good engineering circles it just is not done.

But there are a lot of large building companies employing their own engineering designers who build many welded factory buildings running into a high steel consumption.

There are welding contractors who have purchased mill steel and constructed sizable welded jobs. My first large welded job had to be constructed that way, because every fabricator approached refused to figure or erect it. Today, I know of only one fabricator used to doing riveted work, who actively converts riveted designs to welded structures. They are doing this, because they have discovered that they can make more money through this conversion with its savings in steel tonnage and labor costs, than they can make furnishing rivet work. There has just started, and it is the only one I know, a fabricating shop equipped to do nothing but welded structural work.

In general, the engineers working for these building organizations and electrical appliance companies are the men who have developed the technique of structural welding. They are the young men of today as their forerunners of the past generations were the young men of the age of introduction of steel and the start of reinforced concrete.

Is it not a rather startling parallel, to prove that you cannot keep a source of economy from coming to the front, for these companies who build welded structures know welding saves and benefits or they would not use it.

Why should the present practicing engineer hold back and wait for these present employed engineers to show them all the ropes? These employed engineers deserve great credit for the jobs they have done and are doing, for they certainly are putting the lonely professional on the spot and they are as I see it the engineers of the future for they will know all the answers. They are the true pioneers and deserve the credit which is theirs. Let us all get "welding conscious" before it is too late to join up.

Welding Economies

Now let us see how and why the use of welding creates these economies not securable by any other process of steel assembly and to do this we will start with the engineering design.

In the design of trusses or plate girders the most elementary saving develops through the fact that no holes have to be deducted from tension members to secure net section. In a properly designed welded truss, gusset plates can be practically entirely omitted. In plate girders, flange angles are not needed and single plates can be used for stiffeners instead of using angles. Single plates can be used for flanges.

Truss members carrying compression can be designed for maximum column efficiency by placing the toes of angles together to develop a square section for compression.

On trusses or plate girders it is a fair statement to say that any welded truss or plate girder will weigh 20% less than a similar riveted truss or plate girder.

By the use of welding and the simple connections it develops, it is possible to secure the design economies of rigid frame structures and apply them to structural steel. Heretofore, this has only been economically possible in the use of reinforced concrete, and not economically possible in structural steel, because of the bulky connections required by rivets when used in such designs.

In factory work these rigid designs are permitting the use of the bent rib type of roof construction which gives maximum clear head room with a minimum of space consumption, no diagonal cross bracing members and no shadow lines usually produced by truss members from overhead sky lighting.

In multiple story buildings the rigid frame or continuous beam design saves considerable tonnage which is increased by the simplicity of welded connections for type of work. It also permits the use of shallower beam depths which in turn permits the use of lower story heights.

It is conservative to state that these rigid frames or continuous moment designs will save up to 10% in steel tonnage.

It is probably well here to state that in the average wall bearing interior column type of building, not enough saving can be developed by these methods of design to pay for designing them by these methods. In this type of building it is more economical to use the standard simply supported beam design. In this type of building the savings are accomplished only by the more economical shop and erection costs, for this type of structure can be constructed without field welding which is the most expensive item of a welded job.

It must be that these savings by design methods are familiar to all engineers, so all they need is to learn something about the applied use of welding.

Now saving steel tonnage is one thing and buying your steel for the same tonnage prices as quoted on riveted construction is another which must be accomplished by connection details which will simplify the shop fabrication in order for your tonnage saving to remain as a saving in dollars after the job has been purchased.

Riveting versus Welding

Let us look at the shop and field processes to show that in the welded structure there is less actual shop work involved than is required for riveted work. A step by step comparison for shop processes is about as follows.

It does not take much experience on the part of any one to see that a process which will save all of these steps in production is the more economical process, which in time cannot fail to replace the older riveting process, when more shops become familiar with the welding processes and building codes are revised to remove the restrictions which still continue to exist in some localities.

This very economy and simplicity of welded construction in itself should be cause for careful thought on the part of established fabricators, for here is a method by which one can fabricate and erect a steel structure with only such equipment as a cutting torch, a few clamps and a welding outfit. The danger in the situation arises from the fact that any one who thinks he is a welder and who can secure credit can put such a structure together and should enough of this sort of idea develop the present established fabricator is going to suffer in much the same way as he did when reinforced concrete came along.

These established fabricators with heavy plant overhead due to investment in riveting equipment, which will gradually be used less and less, are now called on to set themselves up with welding equipment to economically handle such welded work as comes along. The result is that neither set of equipment is being used to capacity,

whereas the firm doing only welded work at least does not have the overhead burden of riveting equipment to contend with.

This condition has already developed in the ship building field and is in the process of development in the structural field.

Preparing for Structural Welding

Most of the fabricators in my section have tried to prepare for this situation by putting in the most modern welding equipment such as motor operated sets, operated from power house current rather than gasoline motor equipped sets. They have set aside separate parts of their plants so that steel is unloaded directly on skids, where laying off and welding is done without moving of shapes, so that after welding is completed the steel is either loaded back into cars for reshipment or on trucks for delivery direct to jobs. These firms are being long sighted in preparing the way for a looked for condition and in fact these people because of these plant improvements are beginning to actively ask engineers to permit them to make welded substitutions for riveted work, for they have learned that these substitutions are letting them get the work done on a more economical shop cost, resulting in their making more money.

But as a step beyond this a fabricating plant has recently been started in Pennsylvania to do nothing but welded structural work. This plant is equipped with the most modern automatic welding equipment. They are specializing in manufacture of welded plate girders, welded trusses, etc. This business is being secured by offering these welded members as alternates to riveted members and when you consider that these types of members, welded, show an average saving of 20% over the same members riveted you do not have to believe that these people will find business hard to secure.

This plant with no overhead for obsolete riveting equipment is certainly going to be a tough competitor and as it is probably only the forerunner of similar plants yet to be organized, I speak of this only to urge on the present established fabricator to try to put his plant in condition to economically do welded work, that he may hold this business as it develops, and not let it get away from him as was the case of the advent of reinforced concrete.

We have proved to our own satisfaction that the simplicity of welded work is demonstrated by the figures received on welded jobs compared to similar figures for the same job riveted. In our early work we usually designed a job on a riveted basis, then called for an alternate based on welded work. We never had figures which did not show a saving in favor of the welded job.

Later in our office we began to design jobs as welded work, taking full advantage of all savings such as continuity, lack of holes in tension members, simplicity of connections with the result that when we called for riveted alternates we showed savings in welded work over riveted work, running as high as 20% when we had jobs in which there were a large number of trusses or a good opportunity to develop continuity or rigid frame.

These alternates were required because at the time this was done many of these structures were for public buildings, so, because certain fabricators kept insisting to public authorities that welded work was more expensive than riveted work we had to call for these alternates to prove that they were wrong. For the past five years we have not had this trouble for sufficient work was bid on to convince the most ardent rivet man that he was wrong, for his own shop was bidding the welded job cheaper than the riveted job.

Welding Costs

One of the questions most often asked is, what does welding cost and how much work can a man accomplish in a day? As the welding itself is only a small item in the fabrication process just giving this information is of little help. It is generally asked however on the assumption that other shop and field processes being figurable by an experienced fabricator what can he expect to accomplish so far as the welding itself is concerned.

Taking the average of our jobs we find that the welder on shop work can be figured to apply about 6 to 7 feet of $^3/_8$-inch weld per hour. In field work where the welder moves his own ladders or scaffold we find that a man can average five feet per hour. A good field welder can do about as many connection points in a day as a riveting gang will drive up in a day. This one item gives some idea as to why field erection of a welded job is more economical than riveted work.

In our work on the normal tier building or beam and girder floor job we find that for each ton of structural steel the shop welding will amount to 5 to 7 lineal feet of equivalent $^3/_8$ weld. The field welding amounts to 6 to 9 feet per ton of steel.

A pound of electrode will place slightly over two lineal feet of $^3/_8$-inch weld including allowance for wasted ends of electrode.

In our work we find that the cost of field welding varies from 55¢ to 65¢ per lineal foot in which the welding averages between $^5/_{16}$-inch and $^3/_8$-inch fillet welds. This is the cost at union rates of $1.25 per hour for welders, $1.00 for helper, and an allowance for foreman's time of $1.50 per hour, a hoisting engineer on the welding machine at $1.50 per hour, electrode at 30¢ per pound and electricity at 4¢ per kilowatt hour. This would cover the items on a job where three or more welders are required.

On work not operated on union basis this cost per lineal foot drops to 45 to 50¢ per lineal foot, for in this case a hoisting engineer is not required on the machine and labor rates are lower.

A conservative cost for shop welding would be from 35 to 40¢ per lineal foot of weld. The actual erection costs of steel in a welded job, tier building type of job, are practically the same as the cost of erection of a riveted job up to the time the riveted job is field bolted prior to riveting. At this point the comparison stops for with the type of job we build, plumbing by cable is hardly ever required and the fact that a single welder replaces a riveting gang immediately lowers the cost of the completed welded job compared to the riveted job.

Reliable costs kept by us indicate that when the erector does his own welding, and by this I mean he does not sub out the welding, then the erection costs on our average welded job will run from four to six dollars a ton less than the same job riveted.

The cost of inspection on a welded job averages $1.50 per ton of steel which will include shop and field inspection. We do not require an inspector to be constantly on the job unless more than two welders are working. He is required to see the actual welding of what we would term important parts.

An inspector who knows his work can detect poor welding while it is being placed or after it has been placed. At this point it might be well to state that because we have always insisted on strict qualification tests of men as well as a reference from the man as to previous employers. In the thousands of feet of welding that has been placed in our work the amount of welding we have had to remove is negligible.

We believe this is due to the fact that welders have a

conscientious attitude toward their work and fully realize its importance.

One of the arguments against welding that the inspection is most costly than rivet inspection would not be true if rivets were as carefully inspected as is the case with welding.

From the engineer's viewpoint it is hard to arrive at costs of welded work compared to riveted work due to the fact that so often fabricators will under bid either a riveted or welded job in order to get the job in the type of work he is most used to doing. A riveted job on which a welded alternate is allowed often produces foolish riveted figures as well as foolish welded figures. But, however odd the figures, you can depend on the fact that you have the lowest figures it is possible to get.

Helpful Suggestions

In general the following are a few suggestions which if followed will produce good structural welded work.

Welding can be done under normal conditions at temperatures down to 30° F. If welding is to be done at temperatures below this the material should be preheated to a hand temperature before any welding is started. This preheating may be done by blow torch or other method and should be done near point that arc is to be started. Further heating is not usually required if welding is continued. It is not considered good practice to weld at temperatures below 0° unless special precautions are taken.

Surfaces to be welded should be free from scale or rust. Flame cut edges should be free of slag particles. Welding of painted steel is not objectionable but welding on bare steel is best. Due to protecting steel from weather when field welding is required it is best to specify that such steel be painted with one coat boiled linseed oil. There is less difficulty in welding where the linseed oil is used due to its burning off more easily than when paint pigment is included.

Tack welds to hold parts together should be as small as possible, preferably not longer than one inch and may be included as a part of the final weld if thoroughly cleaned and fused with the final weld.

Reinforcement of welds which are the small sectional raises above the normal weld face are not necessary in structural welding. There is some question as to the benefit of reinforcement.

All fillet welds should be the length of the weld and extend on each end a distance equal to the size of the weld.

Welds should have a bright metallic luster after cleaning. They should be fairly smooth with regular and even spaced ripples and of uniform contour. Good penetration into base metal should be insisted on. This can be observed during welding process by watching depth of crater used by welder during the welding process.

Current used during welding should be that recommended by manufacturer of machine being used.

In fillet welding best results are secured by using $^1/_8$ or $^3/_{16}$-inch diam. electrode for the root or first pass. It is practically impossible to secure good welds using larger rod for the working conditions found on structural work. In multiple layer work larger electrodes may be used for the other layers.

Peening of welds is rarely used on structural work and should only be done when weld is cool to hand temperature.

The defects sometimes occurring in welding are easily corrected. Undercutting, shrinkage cracks, craters, excessive porosity and blowholes by chipping to sound weld or base metal and deposit additional weld metal.

Undersize or excessively hollow welds correct by cleaning and deposit more weld metal.

Overlapping and lack of fusion correct by chipping of weld and rewelding. Overlapping and lack of fusion can be easily detected by chisel point.

Slag inclusions should be removed by chipping or grinding and rewelding.

Base metal if cracked or otherwise defective may be removed by chipping or grinding and reformed to original size by new weld metal.

Stress relieving is not required in most structural work. It can be accomplished locally by heating surfaces to be welded to a cherry red and applying weld metal. This heating can be done by torch or holding arc on surface to be heated.

Residual or locked up stresses and distortion can be reduced to a minimum by using wandering sequence in placing of welding.

In welding of thin pieces to heavy thick pieces as often occurs in structural work it is best to hold the arc toward the heavy piece and build up from it to the thinner piece. This is made necessary due to the fact that the thinner piece does not absorb heat as fast as the thick piece. In the fabrication of plate girders with heavy flange plates this is very necessary and best results are secured by heating flange plates by holding blowtorch on flange plate just ahead of the welding direction.

In plate girder work web plates should be in good contact with flange plate throughout length of girder.

During welding operation there are four principal items to watch.

The sound of arc, which should be a sputtering hiss with irregular crackling sound.

Rate and evenness of burning off of electrode.

The depth of fusion of base metal by observing depth of crater in weld and the evenness of the piling up and forming of the weld bead.

All work should be done by Qualified Welders using procedure qualified welding rod. The recommendations of the AMERICAN WELDING SOCIETY for Standard Methods for Mechanical Testing of Welds of January 18, 1940 give all necessary information for these qualifying processes.

To those who have not used welding and feel reluctance to use it, try to consider a weld as a group of rivets closely spaced one to the other for a weld is nothing more than a number of infinitesimal pieces of steel fused to each other and to the base metal which they join together in much the same way that a string of rivets join pieces together.

No engineer worries greatly about the fact that while these rivets are supposed to entirely fill the holes in which they are placed, they do not do this due to the shrinkage in cooling, nor would he be greatly concerned about a rivet working loose as I have often found in old buildings subject to vibration or normal loading.

A run of weld could have defects in it just as the group of rivets may have but the weld will not fail any more than the group of rivets.

It is a matter of fact that there has been more laboratory and research work done in welding to date than ever was done on rivets and I venture to say that today more is known about the actual behavior of welds than was known about rivets after they were in general use for thirty years.

In fact it is only in recent years that full size group rivet tests have been made to assure one of the correctness of early assumptions made as to rivets.

By the time they know all about rivets we will have no use for the information, for at that time we will all be using welding.

In Conclusion

As I said at the beginning, welding is a better process than riveting, because while it has all of the advantages of riveted work, it is much more elastic in its application and it is more economical. It is just as safe to use and in fact is a more permanent form of connection being just as permanent as the steel itself.

This has been demonstrated in such buildings as the Southern California Edison Company, Los Angeles, which went through a severe earthquake without a weld fracture. Warehouse and shop structures are subjected to constant vibration and overloading. Ships, trains, cars, crane girders, welded steam boilers, tanks, pipe lines, radio towers and equipment of every nature are sufficient evidence to back up the permanency of welding.

I say in the face of all these other uses which have been going on for years, it's up to the engineers and fabricators to give owners the wider benefits resulting from its use in building structures.

There is so much published information available about this subject that today very little time is required to become familiar with it. The new Building Code for Fusion Welding now in process of being developed by the AMERICAN WELDING SOCIETY will be so thorough and comprehensive that using it for a guide an engineer can lay out a welded building with confidence that he will have a satisfactory piece of work.

I appeal to you who are interested to get into this class of work while it is in its growing stages for I can assure you that many of the original research men for the large companies specializing on welding and its equipment and uses are today acting as consulting engineers on welded structures with more work on hand than they can conveniently do. Their early knowledge has served them in the same way the man familiar with reinforced concrete made it serve him when he went into private practice.

So this time let's keep up with this new subject and keep the work where it belongs.

Arc-Welded Design and Construction Applied to Conveyors*

THE USE of belt conveyors has become so common and universal that many companies who maintain an engineer to design their material handling systems merely buy the necessary parts such as pulleys, shafts, bearings, carriers, belting, etc., put them together and have a conveyor. This method is not always satisfactory because one manufacturer is not responsible for the complete installation. It is this practice, however, that makes it difficult for the conveying equipment manufacturer to meet competition profitably. The progressive manufacturer is forced to find some new means through better design, and modern production methods to lower his production costs sufficiently to be able to compete profitably.

The type of conveyors considered thus far because of their construction, their application and installation might well be termed or classified as permanent conveyors. About 1912 another type was introduced. It was made in comparatively short lengths, of light construction and was mounted on a truck for convenience in moving about from place to place. From 1916 this portable type of conveyor became increasingly popular, especially in the coal yard, the material yard, the gravel pit and in the factory. Its first cost was small, its upkeep low and its portability made it available for many jobs. Fundamentally, it consisted of the same basic units that make the permanent type. It was found from building portable conveyors for a number of years that it had many advantages over permanent conveyors. Better materials were built into it to make it light and strong and durable. It was made in units such as drives, sectional trusses of various lengths, take-ups, carriers and hoppers, the common parts of which could be manufactured in quantities at low cost and be put into stock from which could be drawn the necessary combination of units required to make any length and width of conveyor desired. Of course, portable conveyors have limitations of size and length; they must be practical from an operating standpoint.

* Data and illustrations from a study submitted to the James F. Lincoln Arc Welding Foundation by Paul A. Smith, designing engineer, Barber-Greene Company, Aurora, Illinois, in a recent program. In its current $200,000 Industrial Progress Program, which closes June 1, 1942, the Foundation is offering 458 awards from $100 to $13,700, for reports of advances and improvements made by application of arc welding in design, manufacture, fabrication, construction and maintenance.

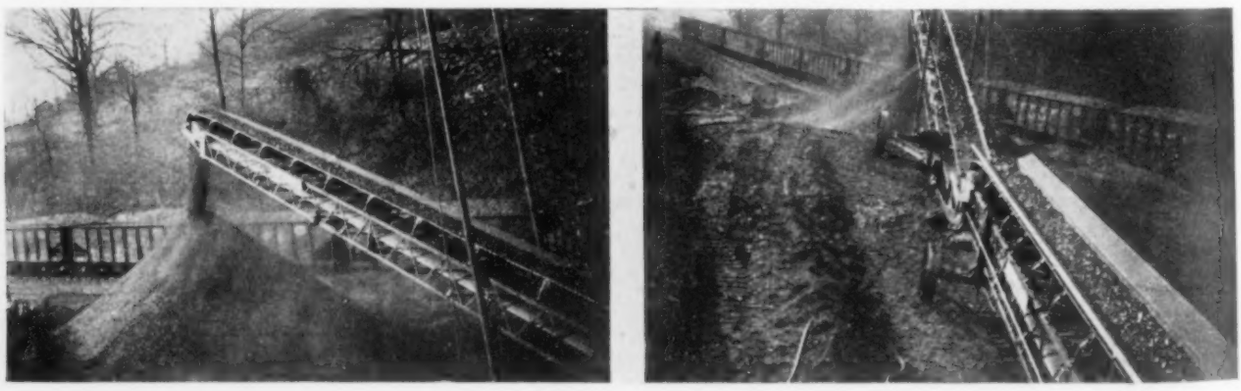


Fig. 1—Typical Portable Conveyor

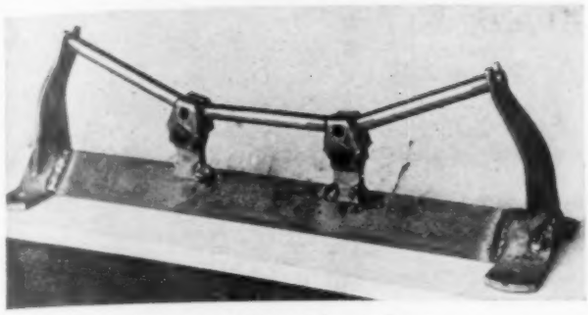


Fig. 2—Arc-Welded Carrier Frame

From this method of manufacturing came the realization that the same principles might also be applied to the manufacture of permanent conveyors. In contemplating the possibilities of this idea it was further assumed that within certain limits both permanents and portables could be standardized, i.e., if a 10 hp. drive is adequate for a certain size portable conveyor, it should be equally adequate for a permanent conveyor requiring no more than 10 hp. to drive it. If a certain type carrier is adequate for one, it should be equally adequate for the other doing the same kind of work. If a structural truss is adequate for a portable conveyor—even though of light construction—which is moved about, often overloaded and abused, it certainly should be adequate for a permanent installation where loads are constant, supports are permanent and the span between supports is predetermined for the safe carrying capacity of the structure. On this basis the two lines which had been manufactured separately for years were both completely redesigned and combined as far as possible. A complete change from riveted to 100% welded construction was made at this time because of the reduction in labor cost and weight of material which is so important in portable conveyors.

The actual work of redesigning these two lines took a lot of time. Many designs were made before one of all-steel all-welded construction was finally adopted.

For the sake of brevity only a portion of the changes made will be described. A few typical examples will serve to show what was accomplished through the application of electric welding in modernizing an old established line. Figure 1 shows a typical portable conveyor.

Trusses.—The "Warren" type truss was adopted many years ago because of its economical construction and universal application made possible by its balanced design which permits all of its members to resist either tension or compression.

The all-welded connection shows a saving of 8.8 pounds of material and $0.82 in labor for each chord connection. Four such connections are required for each joint of two trusses. These trusses average 15 feet in length which means that a 300-foot conveyor requiring 20 sections would show a saving of 117 pounds of steel and $16.40 in labor on this small item alone. It is impossible to make a direct comparison of each point in design throughout the whole truss because the 24-inch deep truss was designed to replace a $17^1/_4$ inch deep truss formerly used; 2 x 2 x $^3/_{16}$ chord angles are now being used instead of the $1^1/_2$ x $1^1/_2$ x $^3/_{16}$ angles in the shallower truss. All other members were increased in proportion to make a balanced structure. A stronger truss was needed which accounts for the deeper heavier truss. The new truss will resist a bending moment of 29,600-foot pounds while the old one was designed for 11,260-foot pounds. The cost per foot is compiled by our cost department based on a 15-foot section. In each case is $0.92 for the 24 inches as against $0.96 per foot for the $17^1/_4$ inches. On a basis of strength, it is readily seen that the welded design, while larger and heavier, is 2.6 times as strong as the riveted type at almost the same cost per foot. The total cost of welding one 15-foot section is $2.60 while the cost of riveting alone (76 rivets at $0.06) was $4.56. While welding does not account for the total difference shown, it was the use of welding that made it possible to design a truss so much stronger at practically the same cost.

Drives.—Conveyor drives vary so much in construction and cost that it is impossible to make a detailed comparison between the various kinds. For the cheap temporary job one can buy crude, rough heavy cast gear drives. For the long-time permanent job the herringbone gear reducer type with anti-friction bearings is generally the highest priced and perhaps will give the longest service. It was our purpose to design a line of drives, all similar in construction, which would be superior in quality to the less expensive, yet having all the desirable features of the highest priced drives. Consideration was given to the limitations of both portables and permanents. Fifteen horsepower figured large enough for the longest portable practical to handle, while 30 horsepower is large enough for many permanent installations. To cover this range economically, we selected three sizes, 5 to $7^1/_2$ hp., and 10 to 15 hp., and 20 to 30 hp., which have been completely designed and standardized. Other sizes will follow as business demands. These drives, which are self-contained, totally enclosed, high-grade steel-bushed roller chains and cut steel spur gears case hardened, are mounted on anti-friction bearings. The housing supports the shafts and is of all-steel 100% welded construction, making it strong and light and oil tight.

All sprockets and gears, are made of cut steel plates welded to steel hubs. This makes light strong construction. It has all the features of the highest priced herringbone reducer—high grade materials, anti-friction bearings, oil tight housing—yet it can be manufactured for much less and be sold in competition with the ordinary open type of spur gear drive. This can best be illustrated with an example furnished by our sales department who have estimated the selling price of three typical drives each of 15 hp. capacity. To be comparable, each drive was figured for a 24-inch belt running at a speed of 300 feet per minute with a 24-inch x 26-inch steel-head pulley, $2^{11}/_{16}$-inch head shaft and necessary structural steel supports. The all-welded design requires less structural supports than either of the other drives because it is built in a self-contained unit not only supporting the machinery but housing the motor as well. This complete unit assembled, less power, sells for $340.00.

An open-type drive consisting of the same size head pulley, shaft, bearings, etc., with the following: a cut spur gear reduction, a $2^7/_{16}$-inch countershaft and bear-

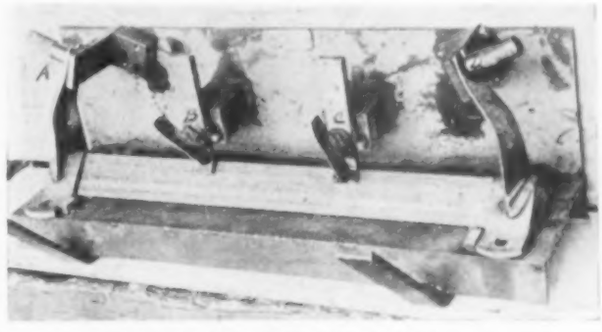


Fig. 3—Welding Fixture for Carrier Frame

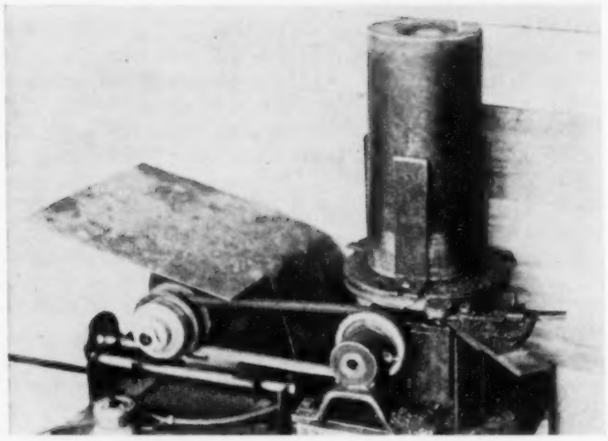


Fig. 4—Dished-End Rolls Arc Welded to Steel Tubing

ings, a chain reduction to motor, an oil-tight chain guard for same, an open-type gear housing, a structural steel support complete, less power, would sell for $401.10.

A reducer type of drive consisting of the same size head pulley, shaft, bearings, etc., with the following: a herringbone gear reducer, 10.8:1 ratio, a chain reduction to the head shaft, an oil-tight chain guard, a structural steel support complete, less power, would sell for $649.85.

Carriers.—It is commonly known to the trade that the carrier is the most important unit in a belt conveyor. Upon it depends largely the life of the belt, the carefree dependable operation that a conveyor is expected to give and the economical use of power to operate.

The latest, most modern development of carrier on the market today is of the anti-friction bearing type (ball or roller), all rolls are alike and interchangeable and the stand is the only all-steel, all-welded stand on the market to the writer's knowledge. It should also be pointed out that the highest type of carrier to be efficient must be accurately made.

In the first place, all the shafts, Fig. 2, must lie in the same plane, otherwise one roller will tend to run the belt to one side while another may tend to run it to the opposite side causing wear on the belt through friction. To insure perfect alignment a welding fixture, Fig. 3, is used. Points *A*, *B*, *C* and *D* of this fixture are accurately located. The end brackets and center supports are clamped rigidly at these points before any welding is done. All parts of this stand are of steel formed in dies (except the structural steel cross angle) which makes them alike and interchangeable. When in position, they are tack welded, then completed as in Fig. 2, which makes an accurate, light, strong, one-piece stand that cannot be broken and will not loosen up. The ordinary stand is made of a structural steel supporting member on which are bolted or riveted rough malleable iron brackets to support the roller shafts. It is impossible to rivet rough castings, such as these, onto a steel member and be sure that the shaft alignment will be perfect. Bolts or rivets are likely to loosen in service which has often been experienced with this type of construction.

Dished-end rolls are welded 100% to steel tubing, Fig. 4. A fixture built for this purpose was made of a worm-gear reducer driven by a small motor. The roll is set vertically and is rotated at the right speed for welding. The welder holds the rod in one position for $^3/_4$ of a minute and the job is done.

The total welding time of both ends of one roll is 2.4 minutes or 7.2 minutes for a three-roll carrier. This carrier, with $5^1/_2$-inch diameter rolls replaced a previous design whose base was a 4-inch bent channel supported on formed steel feet and whose shaft supporting brackets were made of pressed steel bolted to the channel.

A comparative cost analysis of these two carriers (24 inches) is as follows:

	Welded	Bolted
Material and purchased items	Type A	Type B
Bearings, etc.	$5.86	$5.96
Mfg. cost, labor, etc.	2.56	2.81
Assembly	0.40	0.48
	$8.82	$9.25

This analysis shows a saving of $0.10 in material, $0.25 in labor and $0.08 in assembly for the welded type—a total of $0.43 per carrier. While this is a substantial reduction in cost, it should be remembered that the comparison was with a carrier of recent design which was superior in many ways to the ordinary carrier. Due to its bolted construction it was considered of inferior design as soon as the possibilities of an all-welded frame were realized. A reduction in cost was not the only consideration for adopting the all-welded type. It can be more accurately made, is stronger in construction and will not loosen up in service, all of which makes a longer lived, more substantial and more care-free carrier.

SETS OF BOUND VOLUMES OF JOURNAL

In order to provide some of the new members of the Society with an opportunity to complete their library on Current Welding Literature, the AMERICAN WELDING SOCIETY is offering to these new members an opportunity to purchase the last nine bound volumes for the years 1932, 1933, 1934, 1935, 1936, 1937, 1938, 1939 and 1940 at $40.00 a set plus postage. The price to non-members for individual volumes is $6.50 and for the set $45.00 plus postage.

Each bound volume contains a Subject and Authors' Index and is bound in attractive imitation black leather covers. The set probably includes the most important welding information available in the literature.

Welding and Cutting in the Manufacture of Trenching Machines*

By Albert R. Askue†

A TRENCHING machine, as the name implies, is a mechanical substitute for a pick and shovel. Its particular usefulness is in the excavation necessary pursuant to the installation of underground structures such as sewer, gas and water lines, conduits for telephone light and power utilities and the most recent development of gasoline and oil transmission lines across country. Trenching machines have been built for a great many years, the early ones being very large and heavy, and hard to maneuver. The company with which I am connected was the pioneer in making a small, light-weight machine, suitable for use in the cities. The construction of a small, light-weight machine did not, of course, reduce the severity of the service imposed on such a machine. On the contrary, it required a much more efficient machine, if the same work were to be accomplished. This has meant that our problem has always been that of building the maximum of quality and ruggedness with the minimum in weight.

Arc welding and oxyacetylene flame cutting have been of considerable assistance to us in accomplishing this desired result. For the first five or six years all of our frames were fabricated by drilling and hot riveting. As far as frame fabrication is concerned, there are three very important reasons for preferring welding to riveting:

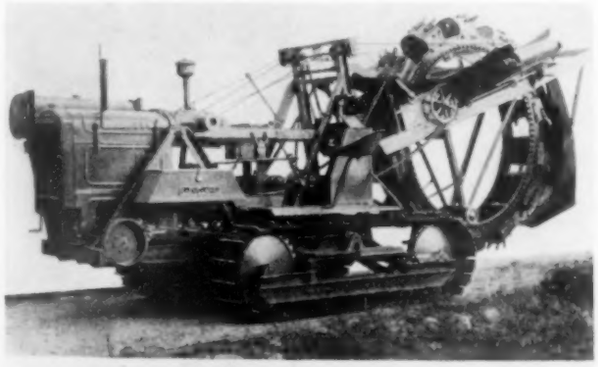
1. Saving in time, therefore decreased cost.
2. Increase in strength.
3. Ease and economy in design changes.

While we are interested in all three of these reasons, the possible increase in strength or a decrease in weight with no reduction in strength is always of paramount importance to us.

* Presented at the Annual Meeting, A. W. S., Cleveland, Ohio, Oct. 21 to 25, 1940.

† The Cleveland Trencher Company, Cleveland, Ohio.

Fig. 1—A Modern Trenching Machine. Cutting and Welding on: Frame, Boom Frame, Buckets, Sprockets, Gear Cases



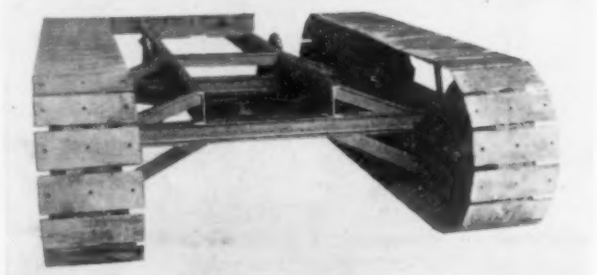


Fig. 2—A Welded Sub-Frame Illustrating the Cross Bracing Which Has Proved Very Effective in Eliminating All Undesirable Weaving in Service

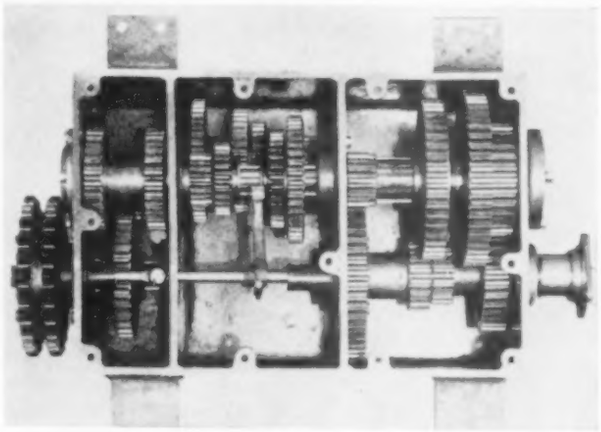


Fig. 3—Sheared Plates, Flame-Cut Bosses for Bearings, All-Welded Case for the Crawler Speed Transmission

Frame Welding

I assume that nearly all of you have at one time or another had an opportunity of watching a trenching machine at work. If so, you may have realized that the entire power or torque of the motor is back of each cutting tooth, and of course, in a reactive way, this power is being transmitted back through the framework and members supporting the digging mechanism. In digging through ordinary soils of a uniform character, the riveted structure was ordinarily quite effective, but when digging through glacial territory with its boulders or in severe rocky going, the rivets would loosen up in a comparatively short time. Since arc welding our frames, the number of failures from any cause have been negligible. We have been arc welding frames for about 10 years, at first using mild steel, then a few of medium carbon steel which was not successful as we did not then know the required technique. About four years ago we started using the high-strength low-alloy steels which became available about that time. As these steels were designed with ease of welding as one of the requirements, they have satisfied our requirements perfectly. We have

had such uniformly good results from their use that we are using them wherever possible, 100% in frames, digging rims and buckets, and in the fabricated crawler sprockets on our larger machines.

The use of these easily weldable steels, with the added strength obtained without increase in weight, has been of particular value to us in building small, light-weight trenching machines. Their use has accomplished the same thing for us in our frame work and buckets that the use of high alloys in shafting and gears had already made possible.

Gear Cases and Transmissions

For quite some time all gear cases and transmissions which are fabricated in our shop have been of all-welded construction. Our reasons for preferring welded cases are:

1. Saving in weight and size.
2. Freedom from flaws.
3. Greater strength.
4. More flexible control of supply.
5. Saving in pattern equipment.

Miscellaneous

We have found it economical in a number of cases to fabricate sprockets by welding a 0.45 carbon plate to a mild steel hub. This is accomplished easily by preheating the parts to be welded over a special gas-fired hot-plate. Jigs and fixtures are, of course, another place where both cutting and welding seem to be almost indispensable. We are constantly finding new uses for welding, mostly for parts which would otherwise be cast. However, once in a while we have found it necessary to replace a welded design with a casting, due to too great complication in cutting and jig work for the welded part.

Flame Cutting and Hardening

Every piece of structural steel or flat material must, of course, be cut before it is ready to use. In the interest of economy, shearing or sawing is utilized wherever possible. Flame cutting must be resorted to where the other two methods are not feasible. The flame-cutting art has in fact progressed to a point where it can in many cases replace machining.

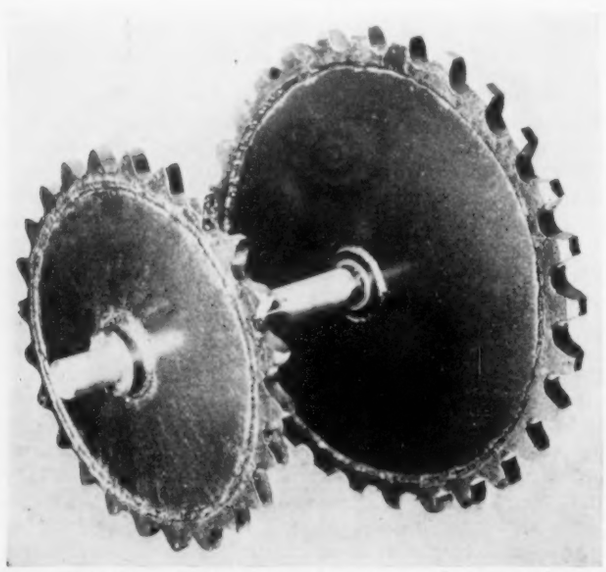


Fig. 4—Welded Crawler Wheels and Sprockets with Flame-Cut Disks and Teeth

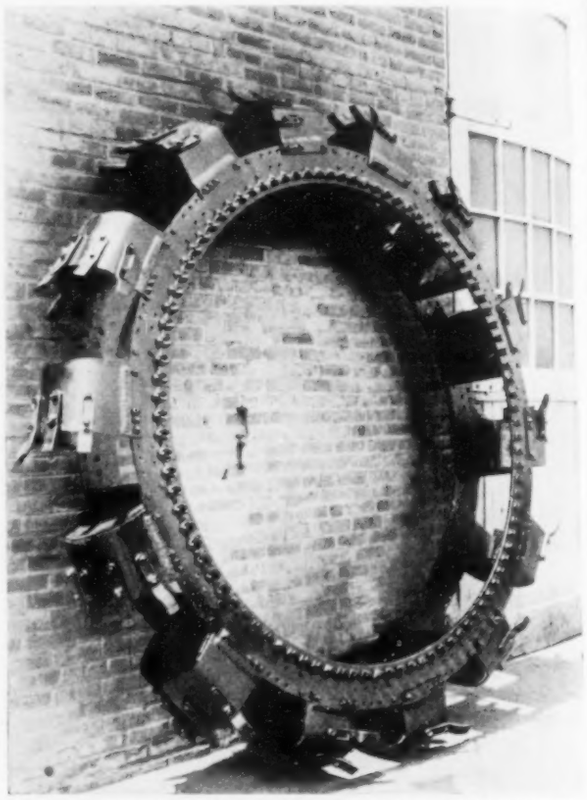


Fig. 5—Welded Segments of 0.35 Carbon Steel. Weld Preheated

A little over two years ago we invested in one of the comparatively new small portable cutting machines, primarily for cutting our digging wheel rims, which are some $6\frac{1}{2}$ feet inside diameter, the rims being 6 inches wide. Its use has resulted in economies and utility far exceeding our expectations. In addition to cutting these rims, the centers left are more than sufficient to supply all the buckets needed, and many other uses have been found for the corner pieces. The percentage of waste from the original square plates purchased probably does not exceed ten or fifteen per cent.

In order to make the most effective use of this machine, we constructed a cutting table, using tee irons with the flats down across the top. These tees are tack welded and are replaced when they become too badly burned for further use. The removable corner brackets serve to support the rims and corner pieces after they are cut. About 99% of all our cutting is done on this table, the corner brackets being removed when not needed. We also made a special light-weight tee-shaped frame for making long radius cuts on small pieces, such as our digging buckets, which are made by one 45 degree bevel cut and three radius rod cuts. Then, as we have use for a great many disks and washers of various sizes, we found it necessary to make up 12 or 15 plates for the machine to run on, each one having a different size hole through which the radius rod center and cutting tip work to cut the material below the plate. The most interesting job developed for this machine is that of preparing the disks for fabricating our crawler wheels and sprockets and finally cutting the sprocket teeth on these wheels.

To a small extent we are also using the oxyacetylene torch for flame hardening and for hard facing the cutting teeth on the digging wheel.

Welding Metallurgy

VOLUME II

By O. H. HENRY and G. E. CLAUSSEN

A series of lectures prepared for presentation in a fundamental course of metallurgy and metallography at Polytechnic Institute of Brooklyn under the joint auspices of the Institute and the New York Section of the AMERICAN WELDING SOCIETY. To be published serially in The Welding Journal. The lectures are reproduced in attractive booklet form, copiously illustrated—357 pages—with imitation black leather covers. Volume 1 consists of the first series of 10 lectures given by the New York Section in cooperation with the Polytechnic Institute of Brooklyn last year. Volume 2 includes the series of lectures to be given this year. The price of the book containing both volumes is $1.50 per copy. Special prices can be arranged for quantity lots of 50 or more.

Part II—The Weld During Cooling

In the preceding section the manner in which a weld cooled was shown, together with the factors which control the cooling. The question arises: what changes occur in the steel during cooling? Before seeking the answer to the question we recall from Part I that the fastest cooling rates occur in the metal which has been heated to the highest temperatures during welding. If we had no prior knowledge, we should conclude that, since the fastest rates of cooling have the greatest effect on steel, the weld metal itself should be the center of discussion. Not so, however, for the weld metal used for nearly all purposes in the welding of steel has so low-carbon content that it does not change its properties to any great extent under the most rapid cooling likely to occur in welding. Besides in multilayer welding the next bead always refines the preceding bead. Instead of the weld metal, therefore, we will examine primarily the base metal in the immediate vicinity of the weld, for it is the metal closest to the weld that cools most rapidly and is most likely to exhibit important changes in structure and properties as a result of welding.

The metal closest to the weld has been heated with extraordinary rapidity to the vicinity of its melting point. During the heating the ferrite and pearlite have changed to austenite. When the austenite is cooled very slowly we know from Part IX of Vol. I that no change occurs in it until the temperature has fallen to the critical range. Upon reaching the upper critical, ferrite crystals form in the grain boundaries of the austenite. As the temperature continues to fall, the ferrite crystals grow until, at the lower critical, the remainder of the austenite changes to pearlite. The corresponding structure for a 0.28% C steel is shown in Fig. 8 (*a*). The upper and lower criticals are the temperatures given by the A_3 and A_1 lines in the iron-carbon diagram.

As the cooling rate is increased, we can no longer rely on the iron-carbon diagram for all we need to know about our 0.28% C steel. We must adopt the view-point that the cooling curve of our steel can be subdivided into a large number of steps, Fig. 9 (*a*). The steel is assumed to remain at a series of temperatures for lengths of time sufficient so that the dotted curve approximates closely

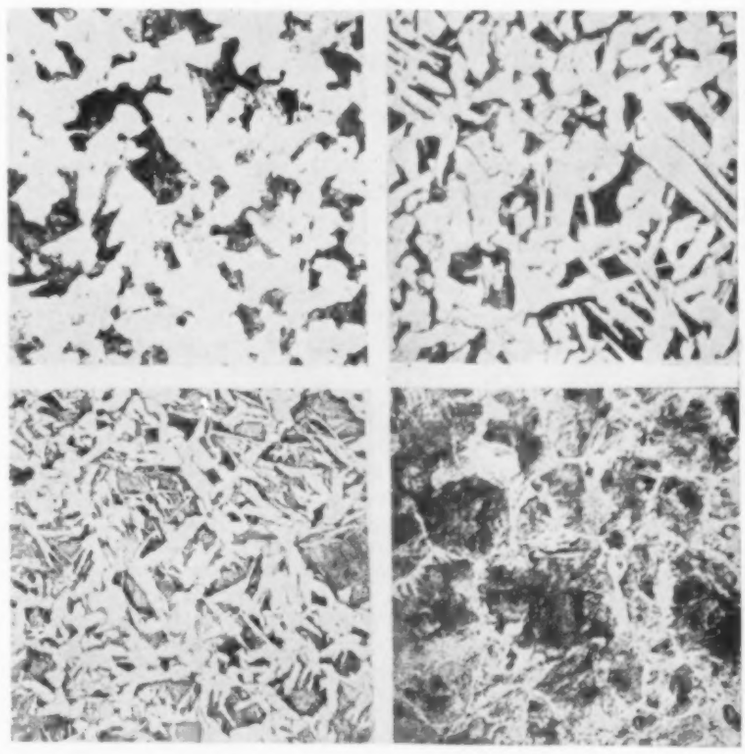


Fig. 8—Microstructure of Steel Containing 0.28% C, 0.53% Mn, 0.18% Si After Cooling at Increasing Rates from Just Above the Upper Critical Range. (Robertson)

(*a*) Upper Left—Slowly cooled in furnace
(*b*) Upper Right—Structure at center of bar 1-inch diameter cooled in air
(*c*) Lower Left—Structure of rod 1/4-inch diameter cooled in air
(*d*) Lower Right—Cooled in molten metal at 540° C.
White = ferrite; dark = pearlite; magnification = 100 diameter
Note increase in space occupied by the relatively hard pearlite as the cooling rate is increased

to the actual curve. The time occupied at each of the selected temperatures then is compared with the time required for the austenite to start changing to other products at those temperatures, Fig. 9 (*b*). For a given cooling rate it is possible to calculate the temperature at which the austenite starts and completes its transformation. The faster the cooling rate, the lower will

be the temperature of transformation; we say that the critical temperature has been lowered.

According to general principles, the number of crystals that form during the transformation increases as the critical temperature is lowered. Thus, in Fig. 8 (*b*) the grains are smaller than in Fig. 8 (*a*) because the cooling rate was more rapid and transformation occurred at a lower temperature. Further increase in rate of cooling still further refines the grain size, Fig. 8 (*c*), for as the number of crystals increases, the size of each must decrease. The structure in Fig. 8 (*c*) is typical of structures found in the heat-affected zones of mild steel welds, (refer to Fig. 62 of Vol. I). A larger proportion of the structure appears to be occupied by pearlite in Fig. 8 (*c*) than in 8 (*a*). Furthermore, the distance between the carbide plates of the pearlite is smaller in Fig. 8 (*c*) than in 8 (*a*). Increase in the rate of cooling of the mild steel below 900° C. results, therefore, in a smaller size of ferrite grain, a small interlamellar spacing in the pearlite, and a lower transformation temperature.

Continuing our inspection of Fig. 9 (*b*), we observe that the curve labeled "fast cool" has never intersected the transformation curve. The austenite represented by this curve will not transform to ferrite and pearlite, but will change instead to martensite at a lower temperature.

S- CURVES

Suppose that before the temperature of martensite formation had been reached we had arrested the cooling by depositing a second bead over the first. If the cooling had been arrested completely, Fig. 9 (*b*), the austenite retained near the first bead would transform to a product known as bainite. Bainite is the mixture of ferrite and cementite to which austenite transforms in the lower part of the S-curve, for example at *A* in Fig. 9 (*b*). Bainite is ferrite containing tiny spheroids of cementite, contrasting with the plates of cementite in pearlite. Instead of growing like pearlite in the manner shown in Fig. 58 of Vol. I, bainite grows like martensite. Regions of austenite suddenly change to bainite by movement of block of atoms. However, the block movement applies only to "lower bainite;" "upper bainite" which forms just under the nose of the S-curve forms by nucleation and growth, as does pearlite.

In the preceding paragraph and in Vol. I (Fig. 68) the S-curve was mentioned, but the transformation curves that were presented, such as Fig. 9 (*b*), resembled only the upper half of the letter S. The austenite-to-ferrite change occurs along these curves, while the austenite-to-martensite change occurs below a maximum temperature. Ordinarily the experimental results are plotted in the shape of the letter S, Fig. 9 (*c*). Each composition of steel has its characteristic S-curve (also called "transformation curve") which varies even for a given steel, with variations in grain size of the austenite and in other factors.

Returning to Fig. 9 (*b*), we see that bainite may form if the second bead arrests the rapid cooling of the austenite at temperatures below the "nose" of the transformation curve, but above the martensite temperature. On the other hand, the temperature of the austenite might be raised by the second bead and ferrite and pearlite might form. Still another possibility is that the austenite had changed partly to martensite and had then been reheated by the second bead into the bainite region. The resulting structure would consist of some bainite and some martensite that had been tempered by reheating, Fig. 9 (*d*).

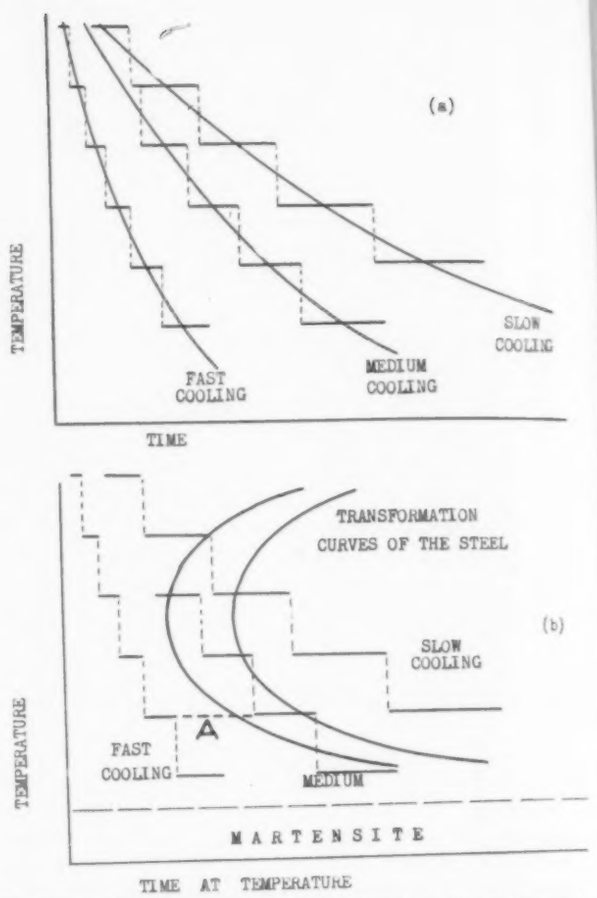


Fig. 9 (*a*) and (*b*)—The Times at the Horizontals in (*a*) are Expressed as a Percentage of the Total Time for Austenite to Transform at Each Temperature for the Purposes of Plotting in (*b*)

Thus, the time represented by the horizontal at 550° C. in (*a*) may be 2 seconds, which may be 10% of the time required to start the transformation of austenite. When the sum of the percentages calculated at the different horizontals in (*a*) equals 100%, the austenite has begun to transform. The fast cooling has exceeded the critical cooling rate, but if the fast cooling had been arrested at *A*, martensite would not have formed

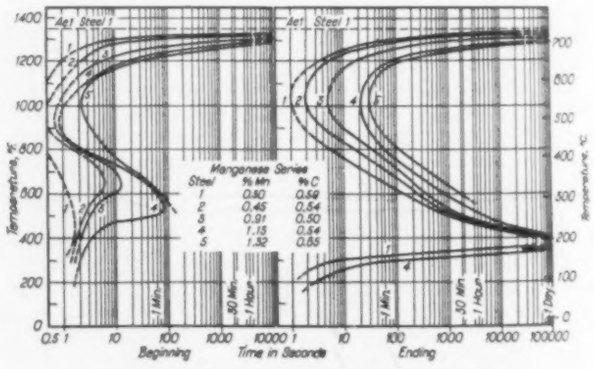


Fig. 9 (*c*)—S-Curves for Carbon-Manganese Steels

(Left) Curves showing the beginning of the transformation of austenite. (Right) Curves showing the end of the transformation of austenite. For example, austenite in the 0.54% C, 0.45 Mn steel commences to decompose in 1½ seconds at 200° C., but the decomposition is complete only after a day has elapsed. A_{e1} = lower critical temperature under equilibrium conditions. Note that only about 1 second is required for austenite to transform completely in 0.54% C steel at the nose of the curve. Adding 1.5% Mn to the steel increases the time for complete transformation at the nose to 2 minutes. (Davenport)

We cannot expect to predict quantitatively the nature of the changes that will occur in the heat-affected zone of a given weld, because the variations in welding conditions, such as depth of fusion, are too great for precise calculations. The discussion of possible conditions serves, nevertheless, to show whence arise the variety of structures that are found in the heat-affected zone of

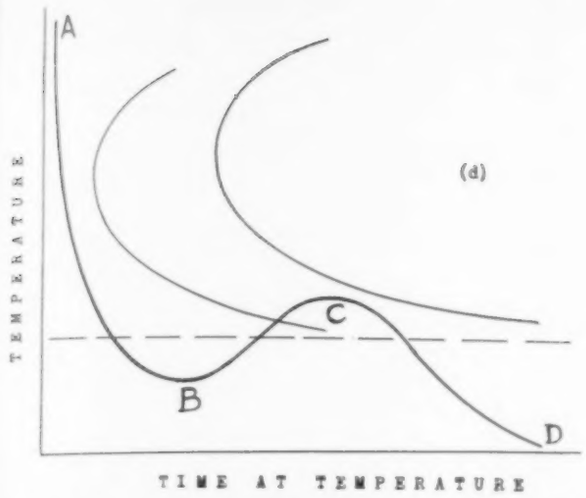


Fig. 9 (*d*)—Curve *ABCD* Is the Time-Temperature Record of the Zone Close to a Weld in Thick Plate

From *A* to *B* the zone is cooling rapidly enough to pass the nose of the transformation curve. As it passes below the martensite temperature, some of the austenite transforms to martensite, the transformation continuing until the temperature falls to *B*. At *B* the zone is feeling the effects of the next bead. The fall in temperature is arrested, likewise the further decomposition of austenite to martensite is stopped. Upon crossing the left transformation curve, the remaining austenite commences to transform to bainite. Meanwhile the martensite is changing to a mixture of ferrite and cementite, that is, the temperature has risen sufficiently high for the martensite to be tempered. Beyond *C* the second bead has passed by and the zone cools to room temperature along curve *CD*. (Caution: Interpretation of time-temperature curves in terms of transformation curves requires consideration of Figs. 9 (*a*) and (*b*)).

welds. As a general rule, the addition of alloying elements, and particularly an increase in carbon content shift the transformation curves to the right. The finer pearlite and martensite tend to appear to an increased extent in the heat-affected zones of the higher-carbon steels compared with the lower carbon. The shift of the curves to the right signifies a decrease in the "critical cooling rate," which is defined as the slowest rate at which a steel can be cooled without the disappearance of martensite.

In the heat-affected zone a wide variety of structures are to be expected corresponding to the wide range of cooling rates in the zone while it is cooling below 700° C. In plain carbon steels with less than 0.20% C the critical cooling rate is so high that, except under most unusual welding conditions, the heat-affected zone will consist of ferrite and pearlite, the individual grains of each being finer the higher the cooling rate. In the higher carbon (0.35% C) and alloy steels (for example, 0.25% C, 1.5% Mn) the critical cooling rate will be sufficiently slow that martensite forms close to welds with high cooling rates, such as the first or root layer of a butt or fillet weld in thick plates. The heat-affected zone will consist of a layer of martensite sandwiched between weld metal and the softer parts of the zone, Fig. 10.

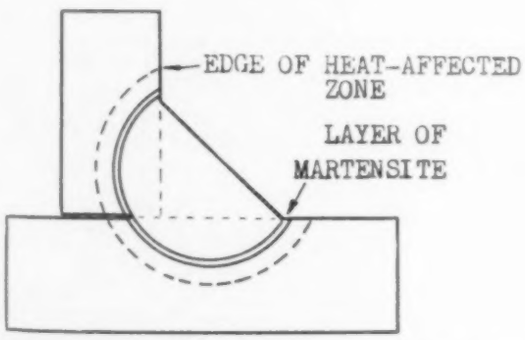


Fig. 10—If Martensite Forms in the Welding of High-Tensile Steels, It Is Found at the Fusion Line

Knowing that there are a number of different structures in the vicinity of any weld, we inquire about their properties, which can be determined on tiny microspecimens cut from the joint or on large specimens that have been heat treated so as to have the same structure as different parts of the weld. Neither procedure is quite satisfactory. Results from tiny specimens $^1/_{16}$-inch diameter are never so accurate as those determined on large specimens $^1/_2$-inch diameter, nor is it certain that there is only one type of structure present even in the tiny specimen. On the other hand, it is not easy to duplicate the structures in a joint by heat treating large specimens, which must be held a long time to attain uniform temperature and never cool at the same rate in the center as on the surface during water quenching. Furthermore, the time-temperature record of a piece of hot steel cooling in a quenching bath, such as oil, has a number of retardations and accelerations, due to flaking of scale, and formation of vapor pockets, that are not found in the time-temperature record of a weld during cooling.

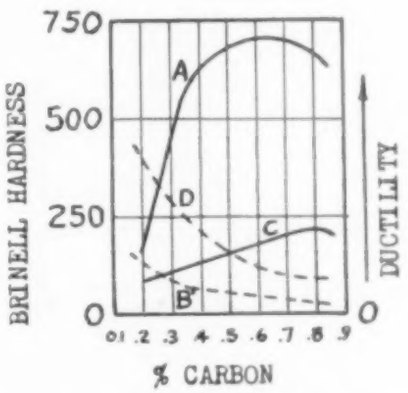


Fig. 11—Hardness (Tensile Strength) and Ductility of Steels as a Function of Carbon Content

The curves for ductility are schematic only; their positions will depend on the stress system prevailing in the test from which the ductility is determined. Addition of alloying elements to the steels may raise the maximum attainable hardness as much as 50 or 100 Brinell units

Curve *A*—Brinell hardness of water-quenched samples
Curve *B*—Ductility of water-quenched samples
Curve *C*—Brinell hardness of annealed samples
Curve *D*—Ductility of annealed samples

With these reservations in mind, we study Fig. 11. The curves labeled "annealed" apply to specimens that have been cooled slowly in a furnace, while the curves labeled "quenched" apply to specimens that have been cooled as rapidly as possible. As the carbon content of the slowly cooled steel rises, the strength and hardness increase, the ductility slowly decreases. The hardness of the quenched specimen rises as the carbon content increases, but quenching has lowered the ductility. The ductility of steels with up to 0.20% C is not greatly lowered by quenching, but with 0.30% C or more quenching lowers the ductility to low values, which would justify the adjective "brittle" for many applications. Cooling rates in a weld fall between the two extremes of "annealed" and "quenched." The faster the cooling, the more nearly the properties will approach the "quenched" curve.

The effect of alloying elements on the curves in Fig. 11 can be estimated only in a general way. For a given hardness the alloy steel will be more ductile than the plain carbon steel. Counterbalancing the advantage of greater ductility in the hardened state is the disadvantage

that the alloy steels of a given carbon content harden at slower cooling rates than the plain carbon steel of the same carbon content.

The benefit of adding alloying elements to steels for welding lies in the utilization of both the greater ductility and the lower critical cooling rate conferred by the alloying element. Quench as drastically as we please, we cannot drive the "quenched" curve in Fig. 11 more than a very few units higher than for plain carbon steels by adding alloying elements. However, in the lower carbon contents (up to 0.20% C) to secure the maximum hardness and strength shown by Fig. 11 nothing less than a drastic quench in water will suffice. Cooling in air will leave the properties close to the annealed condition. With an alloy steel of the same carbon content, however, the critical cooling rate is lower than in the plain carbon steel. Moderate rates of cooling will suffice to create the fine grained structure resembling Fig. 8 (*c*) with which high strength is associated. Furthermore, some of the alloying elements strengthen the steel by dissolving in the iron. The net effect is that regardless of the cooling rate in welding the hardest structure in the weld will have acceptable ductility, yet the as-rolled or normalized low-alloy steel will have high strength.

MARTENSITE

Some of the fundamental facts embodied in Fig. 11 are elaborated in Fig. 12. As the rate of cooling is increased the tensile strength of a mild steel slowly increases; the maximum attainable strength requires rapid quenching, corresponding with the critical cooling rate of the steel. Addition of suitable alloying elements to the steel lowers the critical cooling rate (and incidentally introduces complexities into the transformation curves), and maximum strength is attainable at lower cooling rates than in the unalloyed steel of the same low-carbon content. The tensile strength of a higher-carbon steel, Fig. 12, rises rapidly with increase in cooling rate until the critical cooling rate is reached. Higher rates have no further effect because the martensite produced at any cooling rate higher than the critical is found to be identical in properties with the martensite produced at the critical rate. The ductility of the rapidly cooled higher carbon steel is very low.

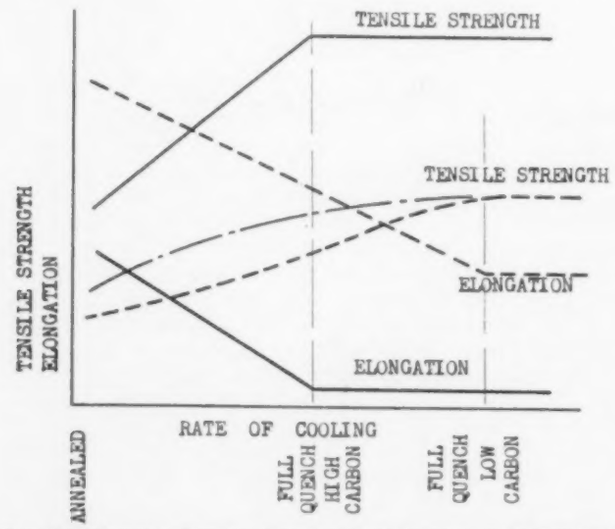


Fig. 12—Schematic Diagram Showing That Increase in Cooling Rate from Above the Critical Range Generally Lowers the Ductility but Raises the Strength of a Given Steel

Low-alloy steels with low carbon content
Low-carbon unalloyed steels
High-carbon steels

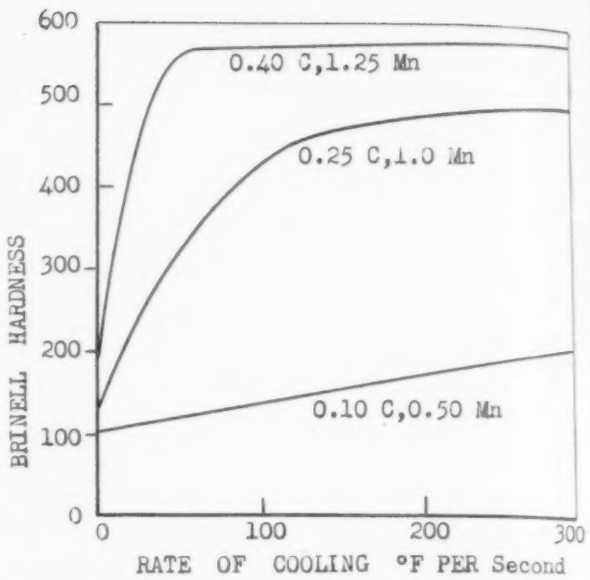


Fig. 13—Hardness of Three Steels After Cooling from Above the Critical Range at Different Rates. (Hodell)

The diagram is applicable only to the three steels. Similar diagrams for many other steels will enter any comparison among steels with respect to hardening characteristics during welding, for which purpose the experimental steels should have coarse austenite grain size to duplicate the size in the heat-affected zone of a weld

Three remarks may be made upon the preceding paragraph. First, the properties of martensite depend on its carbon content; that is, on the carbon content of the steel from which the martensite was formed. Low-carbon martensite is relatively soft and ductile, whereas high-carbon martensite is relatively hard and brittle. Indeed, so large is the difference in properties and behavior of martensite in steels with over 0.6% C compared with martensite in lower-carbon steel, that the two types are believed by some to differ fundamentally. The important thing to remember is that the product of rapidly cooling a low-carbon steel with or without small quantities of alloying elements is relatively ductile.

The second remark is a reminder that the low-alloy, high-yield steels to which reference is made have yield strengths of at least 50,000 lb./in.^{2} (compared with 30,000 lb./in.^{2} for plain carbon steel of the same carbon content) and are made in a wide variety of compositions by the different steel manufacturers.

Third, although Figs. 11 and 12 imply that a steel of given strength and hardness will also possess a corresponding ductility, there is no reliable relationship among strength or hardness (these two are very closely related) and ductility and toughness. To assume, for instance, from the fact that an annealed tool steel of 100,000 lb./in.^{2} tensile strength has 20% reduction of area, that a normalized low alloy steel at the same tensile strength will have the same reduction of area is entirely false. The low-alloy steel will have about 60% reduction of area. Likewise, it is incorrect to draw settled conclusions about the toughness of a welded joint from measurements of hardness in the heat-affected zone. Experiments have shown that although the hardness of the decomposition products of austenite increases as the temperature at which the products were formed is lowered, the ductility in the static tensile test rises and falls in an irregular and as yet unpredictable manner as the temperature of transformation is lowered.

Before following further the subject of the cooling weld, let us bear in mind the function of metallurgy as we have seen it thus far. The weld is polished and etched for microscopic examination. When we examine the

structure, such as pearlite and martensite, we detect structures that we recognize through experience with samples of known heat treatment, and that we know to possess characteristic properties. Whether the properties characteristic of a given structure are retained when the region occupied by the structure is thin, as in the heat-affected zone of a weld, is not known with certainty, but it is a safe guess that any undesirable properties will be retained, although only locally in the narrow zone occupied by the undesirable structure. Fine distinctions among the relative ductilities of different structures observed in the microscope are out of the question. Yet the metallographic detection of martensite in one weld and not in another made by a different process may be a strong argument against the first weld. We may not be able on sight to pick the bandit from a group of suspects, but if we find one of them carrying a gun . . . .

Another function of metallurgy is the matching of cooling rates in the weld with the critical cooling rates of available steels. Each type of weld that we make is characterized by a maximum cooling rate. For practical purposes the cooling rate that is significant is the instantaneous cooling rate at 1300° F., which can be determined by methods outlined in Part I of Vol II. Furthermore, every type of steel has a different critical cooling rate, which, if it is exceeded, causes the appearance of martensite. Recalling our discussion of Fig. 12, we know that martensite appears in low-carbon steel only if extraordinarily high cooling rates are employed;

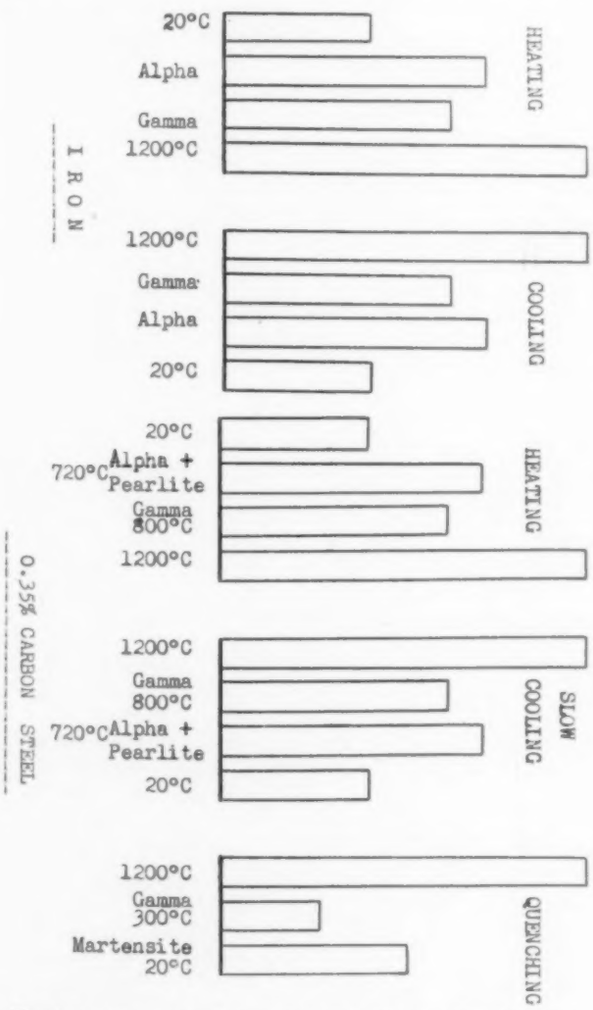


Fig. 14 (a)—Changes in Volume (Length) of Iron and Steel During Slow Heating and Cooling

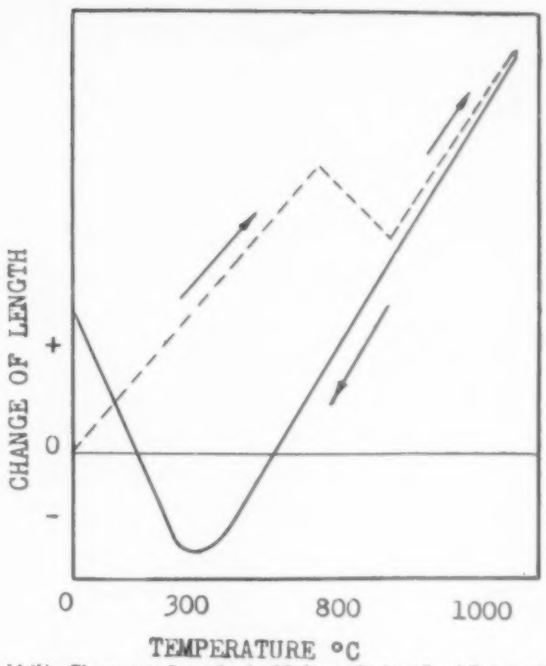


Fig. 14 (b)—Changes in Length of a Medium-Carbon Steel During Heating and Quenching

- - - - - - - - - - - - - - - - - - Heating
——————————— Quenching

The densities and specific volumes of 0.9% C steel in three different conditions at room temperature are:

Condition	Specific Volume, Cubic Centimeters per Gram	Density, Grams per Cubic Centimeter
Pearlite—0.9% C steel	0.1286	7.778
Austenite—0.9% C steel	0.1275	7.843
Martensite—0.9% C steel	0.1310	7.633
Iron	0.1271	7.864
Cementite	0.1304	7.67

The difference in specific volume between martensite and pearlite is less in the lower-carbon steels than in 0.9% C steel. On heating when alpha iron changes to gamma iron at 910° C. there is a contraction in volume of 0.846%; when gamma iron changes to delta iron there is an expansion in volume of 0.255%; when iron melts there is an expansion in volume of 3.6%. The reverse changes occur on slow cooling

besides, low-carbon martensite is ductile. In the higher-carbon (over 0.20% C) and low-alloy structural steels the appearance of martensite signifies hardness and lack of ductility. Consequently, in selecting a high-tensile steel for welding, we must be certain that the maximum cooling rate in the weld is less than the critical cooling rate of the steel.

Before we can apply the method in practice we must modify it in the interests of simplicity and safety. Instead of using the appearance of martensite as a criterion, it is safer to confine the maximum permissible hardness near the weld to some value such as 200 Brinell, which experience has taught us is safe. We then determine the cooling rate required to cause the steel to reach 200 Brinell, Fig. 13. If the maximum cooling rate (at 1300° F.) in the weld is less than 20° C./sec., it is obviously safe to use the steel containing 0.25% C, 1.5% Mn, but unsafe to use the higher-carbon steel. In estimating the maximum cooling rate in any type of weld it must be remembered that nearly always tack welds must be made, which also must not cause undue hardness. The cooling rate is always higher in a short tack weld than in a long weld, because at the beginning of a weld the temperature has not had time to attain equilibrium in advance of the bead. The gradual increase in depth of penetration of a weld bead in the first inch or so reflects the gradual attainment of temperature equilibrium.

EXPANSION AND CONTRACTION

In addition to changes in temperature and structure during the cooling of a weld, there are changes in the

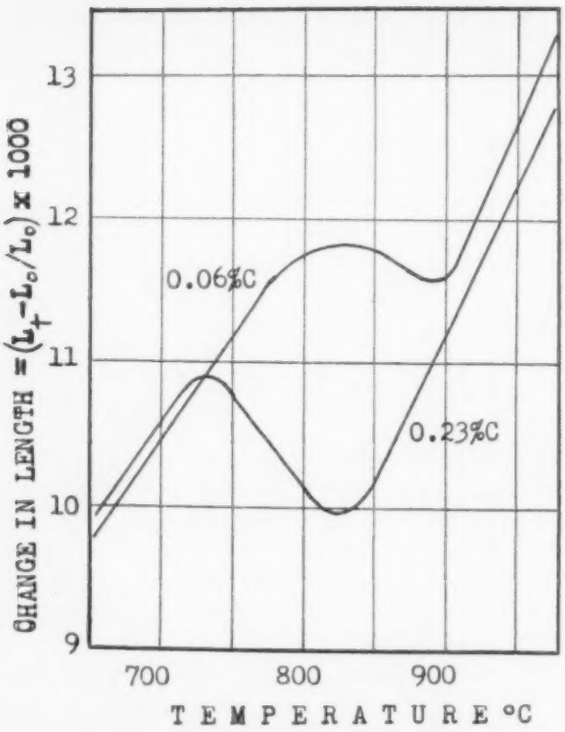


Fig. 14 (c)—The Dilatation Curves Show the Expansion of Two Plain-Carbon Steels During Slow Cooling Through the Critical Range. (Griffiths)

L_t = Length at t° C.
L_o = Length at 0° C.

Metals without critical ranges, such as 25% Cr–12% Ni steel, contract uniformly during cooling

volume of the steel, Fig. 14. Iron, upon heating, expands until at 900° C. it commences to change from the alpha to the gamma form. The gamma form is denser than the alpha at 900° C., and during the transformation to gamma the steel contracts. Once completely transformed to gamma, the iron expands upon being heated to still higher temperatures, and expands at a greater rate than in the alpha form because the coefficient of expansion of gamma iron is 18×10^{-6} per ° C. whereas the coefficient for alpha is only 12×10^{-6} per ° C. In other words, gamma iron expands 0.000018 inch in a length of 1 inch for each degree Centigrade rise in temperature, whereas alpha iron expands 0.000012 inch. If, instead of carbon-free iron, 0.35% C steel is heated, the alpha iron in the pearlite changes to the gamma form and dissolves the carbide at the lower critical, 720° C., accompanied by a contraction. The remaining alpha gradually transforms to gamma while the temperature rises to the upper critical for the 0.35% C steel: 800° C. Above 800° C. the gamma (austenite) expands as in carbon-free iron.

During slow cooling the contractions and expansions are exactly the reverse of those observed on heating. If, however, the cooling is rapid, faster than the critical cooling rate for the steel, the austenite transforms only below about 300° C. While it has been cooling below the critical temperature it has been contracting more rapidly than ferrite. Accordingly the sample may be denser (shorter) at 300° C. than was the steel initially. At 300° C., however, the austenite transforms to martensite, which is the most voluminous (least dense) form in which steel exists at room temperature. On this account the steel expands abnormally during further rapid cooling from 300° C. to room temperature, Fig. 14 (*b*). With these facts in mind, it is an interesting exercise to visualize the straining and squeezing undergone by the steel near a weld during welding. As the weld puddle approaches, all the steel in the vicinity expands. The steel heated above the critical contracts in passing through the critical range before expanding further. After the puddle has passed by, contraction sets in, with expansion occurring during the passage through the critical range for those regions that have been heated above it.

There may be a region close to the weld that cools so rapidly as to harden (become martensitic). The rapidly cooling zone contracts abnormally until at about 300° C., when all the steel surrounding it on the base metal side has cooled below 300° C., and the weld metal itself is not far above 300° C. (and also contracting for it is low-carbon steel with a very high critical cooling rate)—under these rigid conditions, then, the rapidly cooling zone expands. We do not yet fully comprehend the consequences. The circumstances become further complicated with alloy steels the austenite of which may transform in a different manner and at different temperatures from plain-carbon steels. Since long, cylindrical bars of steel heated slowly above the critical range and slowly cooled undergo a permanent change in length, usually a decrease in length tending to change the bar to a cube or sphere, it is not surprising that a little distortion is not uncommon in welding (see Part IV of Vol. II).

The zone that is heated above the lower critical but not above the upper critical during welding is of interest, because it is known that mild steel (up to 0.20% C or so) quenched from slightly above A_1 loses a great deal of its ductility. To cite an example, the Izod notch impact value of a mild steel (0.10% C) quenched in water from 725° C. (slightly above the lower critical) was only 10 ft.-lb., whereas after quenching from 825° C. the Izod value was 80 ft.-lb. The cause of the embrittlement can be seen from Fig. 15. Heating to slightly above the lower critical converts pearlite to austenite containing about 0.8% C, which tends to form in the grain boundaries and envelope the remaining grains of nearly gamma-free ferrite. Quenching, by converting austenite to martensite, surrounds the ductile ferrite grains with brittle, high-carbon martensite. Under stress the brittle martensite envelopes govern the ductility, which is low. If the steel is cooled slowly from 725° C., the austenite regions transform to patches of fine grains of ferrite and pearlite, and the steel has high ductility. Ductility is retained, too, if the steel is quenched from 825° C., for at this temperature the austenite dissolves nearly all the ferrite and has, therefore, a low-carbon content, as the iron-carbon diagram shows. Low-carbon martensite has comparatively high ductility and unusually high notch impact value. These results hold little significance for the welding of mild steel, for it is very rare that the zone heated only just above A_1 during welding cools at such a rate as to transform the austenite to martensite.

Before leaving the subject of the cooling of the weld and the hardening of steel, we may recall that there are many high-alloy steels that cannot be quench hardened. The most familiar of them is 18–8 (18% Cr, 8% Ni), which remains austenitic under ordinary conditions at all temperatures. Another familiar heat-resisting steel

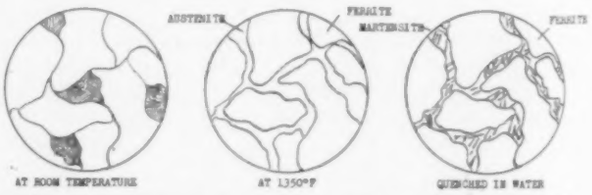


Fig. 15—Intergranular Martensite in Low-Carbon Steel Quenched from Within the Critical Range

that cannot be quench hardened is 28% Cr iron, which is ferritic at all temperatures. These steels can be hardened at room temperature only by cold work.

Questions

1. Why do the structures of the products of decomposition of austenite and their degree of subdivision depend on cooling rate?
2. Distinguish between critical range and critical cooling rate.
3. If martensite is found in the heat-affected zone of a given weld, why will changing the steel to a shallower hardening type tend to prevent the appearance of martensite?

Stack-Cutting Hints

By E. P. Jones*

Correct Starting of Cut Important for Satisfactory Results

IN ANY stack-cutting operation certain advance preparations, such as proper cleaning, stacking, and clamping of the plates or sheets, are necessary to help assure satisfactory results. However, this preparatory work may be wasted so far as results are concerned if the cut is not started properly. A false start usually damages the edges of several plates, and produces such conditions at the starting point that a second start is extremely difficult. For this reason, it may be said that in some respects the starting of the cut on stacked plates is the most important part of the operating technique. To guard against mishap at the beginning of the cut, several methods of starting are commonly employed, as shown in the accompanying sketches.

Staggered-Pile Method

Sketch (*A*) illustrates one of the most simple methods. The plates are piled so that each plate in the stack projects slightly beyond the one below. Although the individual plates are well aligned with one another, the edge of the stack at which the cut is to be started slopes slightly inward from top to bottom.

Plate or sheet stacked in this way is cut in the same manner as a single piece of metal. After the blowpipe has been lighted and adjusted, the cut is begun as usual. Cutting action, however, starts in the top plate first, and gradually progresses down through the stack, plate by plate, as the blowpipe advances. This starting procedure, known as the staggered-pile method, consistently yields cut surfaces of high quality.

Swinging-Blowpipe Method

The swinging-blowpipe method is another cut-starting method which is used extensively. The stack is prepared and clamped in the normal manner, but the cutting machine is fitted with a special attachment for holding the blowpipe. This attachment provides for adjustment of the blowpipe at an angle along the line of cut.

The starting procedure is the same as in other machine-cutting operations, except that the blowpipe nozzle is slanted away from the stack at the start, as in (*B*). Cutting progresses downward through the stack as the nozzle advances at the set angle. When the cut pierces through the whole stack, the blowpipe is adjusted back to vertical for the remainder of the cut. This adjustment must be completed while still cutting in the scrap material.

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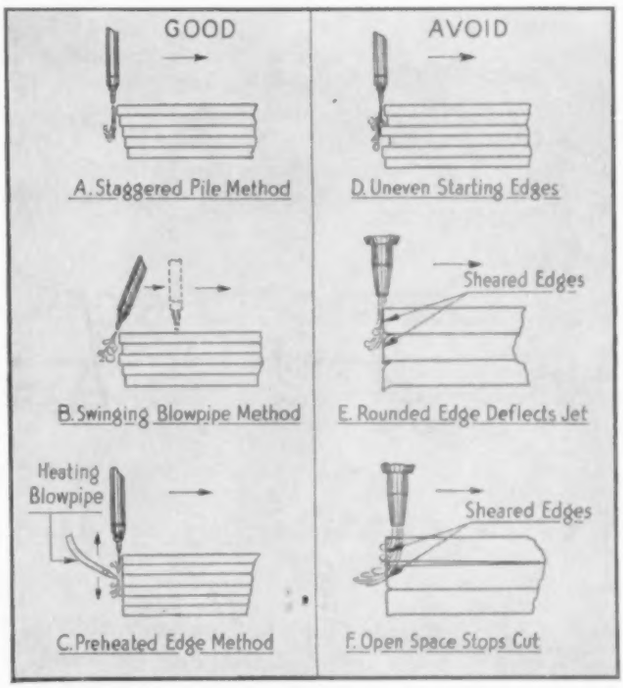


Good Starting Practices Are Shown in (A), (B), and (C). Poor Starting Practices in (D), (E), and (F) Should Be Avoided. Arrows Indicate Direction of Blowpipe Motion

Starting a cut by the swinging blowpipe method has the advantage of requiring less care in the alignment of the plates in the stack, but requires extra blowpipe manipulation during cutting.

Preheated-Edge Method

A third starting procedure, identified as the preheated-edge method, is the simplest of all and is highly effective provided the edges of the plate or sheet in the stack are straight and square. The stack of plates is built up to the desired height and arranged so that the starting edges are aligned vertically before clamping. Uneven edges like those in (*D*) are avoided.

As soon as the cutting blowpipe has been lighted and properly adjusted and the cutting machine is ready to be started, the flame of a welding blowpipe is played on the edge of the stack at the starting point of the cut. As indicated in sketch (*C*), the heating blowpipe is moved up and down across the edge of the stack until the edges of the plate are brought to the kindling temperature. Then the cutting machine is moved into position and the cut is started.

Cutting Sheared Plates

Improper piling of sheared plates often makes the starting of a cut more difficult than it should be. Plate edges

cut with the average shear are slightly rounded at the top and have a deformed bottom edge which has been distorted downward by the action of the shear blade.

If the sheared plates are piled so that the rounded edges face upward, these rounded edges will have a tendency to deflect the cutting jet, as in (*E*), and result in a false start. On the other hand, wherever deformed bottom edges face each other in the stack, open spaces are formed between the plates, as shown in sketch (*F*). Such open spaces usually will stop the cut.

One way of avoiding both of these difficulties is to select plate which has at least one oxyacetylene-cut edge at which to start the cut. When this is not practicable, stack the sheared plates so that all of the *rounded* edges face *downward* and cut by any of the methods previously described.

Inside Cuts

Conditions often arise where cutting cannot be started from the edge of the stack. Under these circumstances a drilled hole serves as a starting point and special care must be exercised to avoid a false start. First, all burrs should be removed from the edges of the drilled holes; second, the p ates should be stacked carefully so that the sides of the holes are in vertical alignment.

If the drilling operation is accomplished after the plates are clamped in position, alignment of the holes is no problem but, where this is impracticable, alignment is easily assured by inserting a bolt or drift pin of proper diameter through the holes to hold the plates in position until they are clamped together. Upon removal of the bolt or drift pin, the cut can be started at the hole without difficulty.

Oxyacetylene Welding of Light Aircraft*

By Hanford Eckman†

BY DEFINITION, the light plane is one that has an engine of 75 hp. or less. It is also recognized as having a high ratio of weight to power (power loading) and a low ratio of weight to wing area (wing loading). In the light plane field, perhaps even more than in the balance of the aircraft manufacturing industry, mass-production principles, as practiced, for example, in the automotive industry, do not generally apply. True, these principles do play an important part in many of the outside sources of supply, such as among the engine makers, and automatic machines also help to reduce hand operations. The present light plane, though, is still, in large part, a handmade product in the creation of which welding plays a prominent part.

This discussion will be confined to the use of oxyacetylene welding in the production of light planes, designed principally for private use as differentiated from military and commercial aircraft of higher performance. In our field, the welding of light-walled tubing is practiced most extensively in the fabrication of fuselages. For the light plane, welded tubular design at present allows the most satisfactory method of construction because it permits a high rate of production with a minimum of special tools and jigs.

Welded tubular design has a high ratio of strength to weight. Moreover, welded joints are highly efficient and rigid and, at the same time, light in weight. This type of assembly permits great flexibility of design and is economical to fabricate and to maintain.

Development of Welded Tubular Construction

Perhaps a review of the development of welded tubular construction in the aircraft industry will help to indicate present trends in design and materials. When metal first replaced wood in aircraft members, carbon steels were employed. These are still used, as represented by the S. A. E. 1025 or similar steels. Joint design and welding technique for this material were thoroughly investigated both in the field and in the laboratory. As the industry developed, higher speeds were attained in aircraft and greater stresses resulted. In the search for lighter or stronger materials, alloy steels were introduced. S. A. E. 4130 and S. A. E. X4130 or their equivalents have been widely used.

There are a number of specifications written to cover carbon steels and chromium-molybdenum steels in various industries, and particularly in the aircraft industry. The following table is representative of these steels. It will be of assistance in making a comparison of the physical

Chemical Composition

	Carbon, %	Manganese, %	Chromium, %	Molybdenum, %
S. A. E. 1025	0.20–0.30	0.30–0.60	...	...
S. A. E. X4130	0.25–0.35	0.40–0.60	0.80–1.10	0.15–0.25

Physical Properties

	Approx. Tempering Temperature, ° F.	Minimum Tensile Strength, Lb. per Sq. In.	Elongation, Per Cent in 2 In.
S. A. E. 1025		55,000	22
S. A. E. X4130, normalized		90,000–95,000*	5–15*
S. A. E. X4130, oil-quenched	1100	125,000*	11*
	900	150,000*	9*
	800	175,000*	7*
	600	200,000*	5*

* Light gages—minimum ductility—maximum tensile strength.

* Presented at the Annual Meeting, A. W. S., Cleveland, Ohio, Oct. 21 to 25, 1940.

† Production Manager and Superintendent, Piper Aircraft Corporation, Lock Haven, Penna.

properties of the chromium-molybdenum and the carbon steels.

The most noticeable differences in physical properties between chromium-molybdenum steels and plain carbon steels are found in the relative tensile strength and ductility. The chromium-molybdenum steels, because of their greater strength and ductility, are highly suitable for use in aircraft construction. These alloy steels also offer greater possibilities of heat treatment. This and the fact that they air harden have necessitated certain changes in welding technique. A discussion of some of the significant factors in welding, which are common to welding both plain carbon steel and chromium-molybdenum steel, will help to trace the development and to show the advantages of present-day technique.

Metallurgy of Welding Plain Carbon Steel

As steel is heated it undergoes several alterations of physical properties. When the temperature is increased, the steel expands, becomes softer and more ductile and, particularly at elevated temperatures, becomes weaker from the standpoint of tensile strength. It is fortunate from the view-point of the fabricator that these changes in physical characteristics are coincidental, because the collective phenomena make possible the joining of several members into a high-strength structure by means of fusion welding. When heat is applied locally, expansion takes place in the heated zone; but because the ductility is increased, the area over which the stresses are distributed is increased and the material does not rupture. Of course the piece should be free to move sufficiently to absorb expansion and contraction, so that no undue stress is put on the hot, low-strength material.

When heat is continuously applied, the temperature rises to a series of recalescence points. In plain carbon steels these start at about 1360° F. The metallurgical changes that take place here have a very practical significance. The carbon, which at lower temperatures has existed as discrete particles of iron carbide mixed with pure iron, goes into solution in the iron and remains in solid solution at temperatures above this point. On cooling slowly through this temperature, the carbon is again precipitated or thrown out as iron carbide. More rapid cooling tends to retard the reaction and to retain the carbon in solution.

Recrystallization takes place at about the same temperature as recalescence. When heated much above the critical point, steel crystals tend to grow in size to an extent depending on the length of time at the temperature and the amount the temperature exceeds the critical point. The shorter the time that the steel is held above the critical point and the lower the temperature, the finer the crystals will be and the better the physical properties.

That steel reacts with oxygen at all temperatures is illustrated by the rusting action at ordinary temperatures and by the adherent oxide scale that is found on hot-rolled or forged stock. When stock is reheated, the carbon in the adjacent steel begins to react with the iron oxide. The oxide is reduced and the products of the reaction escape as a gas. Migration of carbon is rapid and decarburization may proceed to a considerable depth. The reaction is accelerated as the steel becomes molten.

In oxyacetylene welding, the surface of both the base metal and the welding rod becomes coated with iron oxide or scale while heating up to welding temperature. Further, the iron oxide has a lower melting point than steel and must be removed to secure a sound weld.

Welding Chromium-Molybdenum Tubing

These physical, metallurgical and chemical factors in welding become more significant with the wider use of alloy steels. They are of considerable importance in welding light-walled chromium-molybdenum tubing. The air-hardening qualities and resulting high tensile strength and reduced ductility indicate that more attention has to be given to expansion and contraction of the steel, and to insuring that undue stress is not placed on the hot metal. Though molybdenum is present to inhibit grain growth, it is desirable to reduce the temperature and the time that the steel is held above the critical point to a minimum. Furthermore, with thin-walled tubing, decarburization of a very small portion of the wall thickness affects an appreciable percentage of the area of the cross section. To obtain efficient joints in the alloy steel, the welding rod must have a tensile strength comparable to that of the chromium-molybdenum tubing and welds made with it must react favorably to heat treatment.

Welding Rods

The first oxyacetylene welding rods which gave good quality welds were low in carbon and contained a mini-

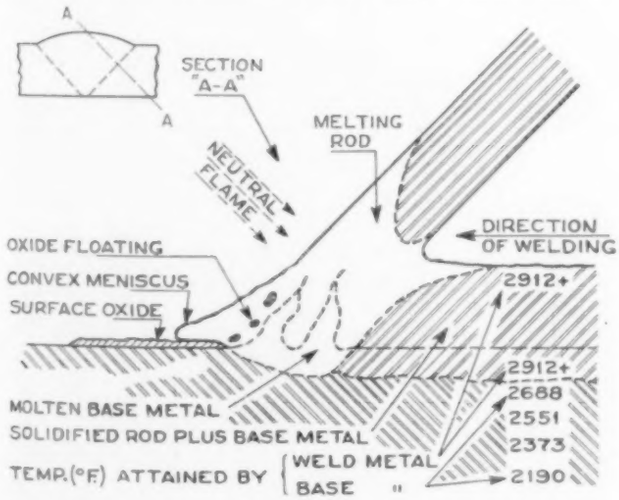


Fig. 1—This Sketch Indicates Metallurgical Factors in Neutral Flame Welding

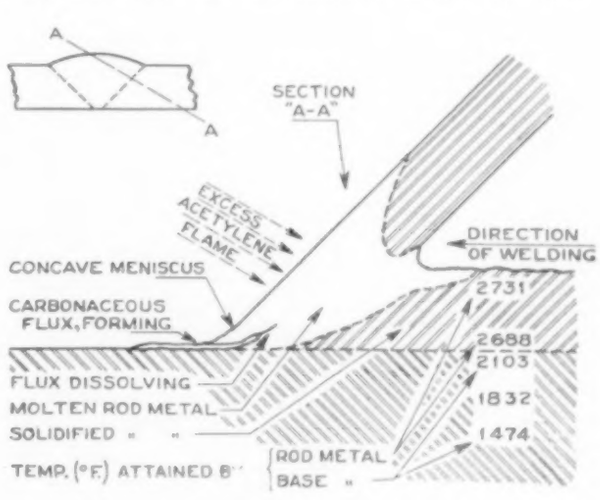


Fig. 2—This Sketch Indicates Metallurgical Factors in Excess Acetylene Welding

Fig. 3—These Are Part of the 400-Odd Bronze-Welded Jigs Used in Shaping Tube Stock

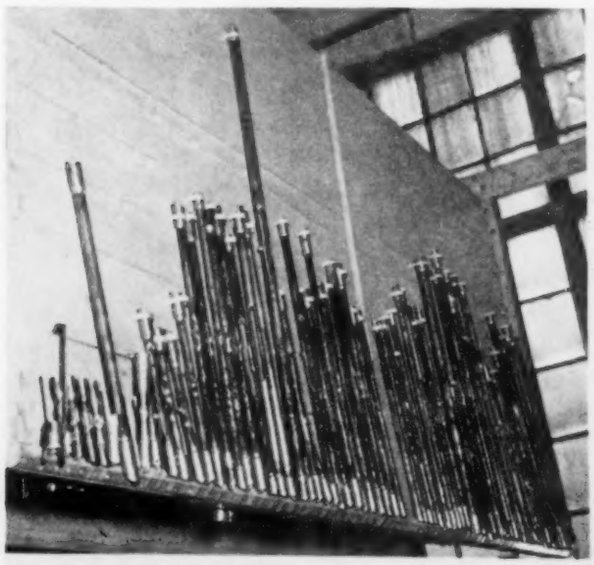
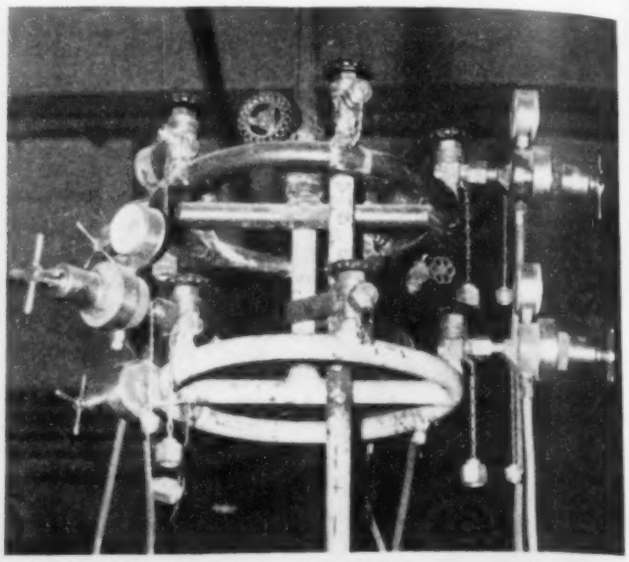


Fig. 5—Floor Space Is Conserved by Supplying Oxygen and Acetylene to Welding Stations Through Drop Rings



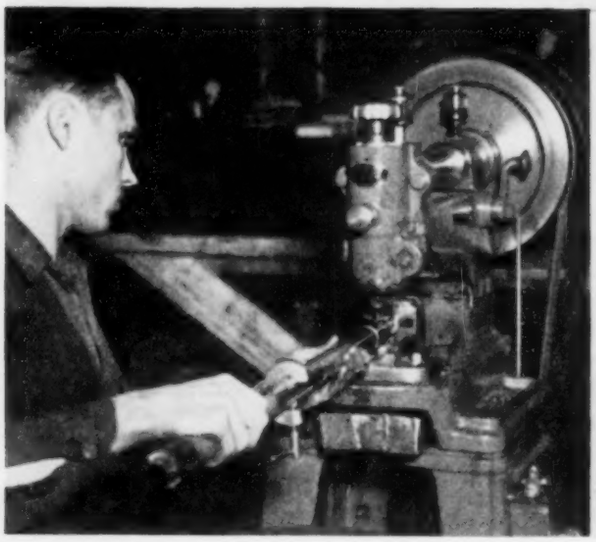


Fig. 4—This Bronze-Welded Jig Is Being Used for Shaping the Ends of a Tubular Member

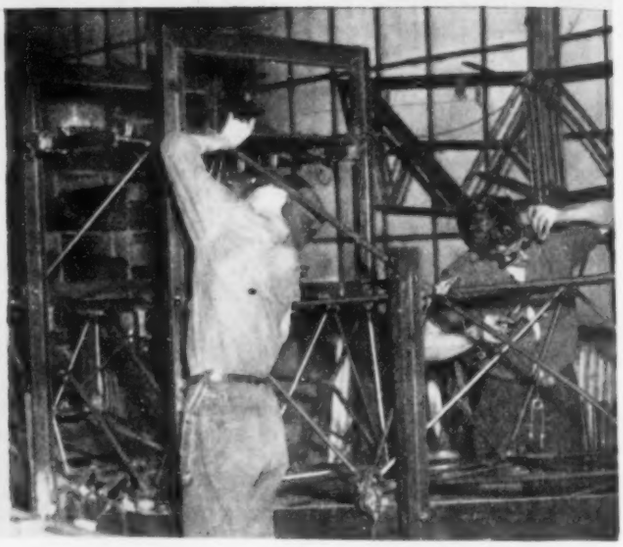


Fig. 6—Fuselages of Chromium-Molybdenum Tubing Are First Tack-Welded in Jigs

mum of other elements. This was reflected in the welding technique used. To obtain adhesion between the added metal and the base metal, a considerable amount of the latter was melted to make sure the oxide was removed. To eliminate the iron oxide from the weld, the weld metal was heated well above melting temperature to obtain fluidity. As a result the weld was reduced in carbon and was low in tensile strength as compared with the results obtainable today. The carbon content of the rod had to be low to avoid excessive reaction between it and the large amounts of iron oxide that were present.

As the welding industry has developed and knowledge of the needs and problems has increased, new welding rods have been devised in which manganese and silicon have been added to reduce the iron oxide. With these, the products of the reaction are solids which form a fluid slag that floats to the top of the molten puddle. This effectively cleans the weld metal and protects it from further oxidation. The elimination of the carbon-iron oxide reaction in the weld makes it possible to increase the carbon content of this type of rod. Consequently the strength of the weld metal is increased and a sounder deposit is obtained. The active reducing agents readily remove the oxides, thereby making excessive melting of the base metal or temperatures much above melting point unnecessary. The welding technique, though, is still very similar and a neutral flame adjustment is used.

Figure 1 illustrates the action of the welding puddle. The temperatures are representative of those obtained in a cross section of a weld.

This type of welding rod and welding technique is widely used in the fabrication of tubular members. It is very satisfactory when used on straight carbon steels as with S. A. E. 1025 and good results are obtained with some chromium-molybdenum steels, particularly if care is taken to allow for expansion stresses and if heating is held to a minimum to inhibit grain growth. A later advance in welding procedure has further assisted in the welding of chromium-molybdenum tubing.

Welding with Excess Acetylene Flame

The newer process for oxyacetylene welding utilizes certain distinct but cooperating properties of carbon and iron. The underlying principle of the process is comprised of the following relations: carbon is soluble in iron; carbon lowers the melting point of the mixture; this melting point is in the feasible welding temperature range; carbon reduces iron oxide; the non-metallic product of the reaction is gaseous and escapes.

If a piece of steel is heated to somewhat below welding temperature and is exposed to a carburizing influence, the surface layer of the white-hot metal will absorb carbon and will melt spontaneously as the carbon approaches the eutectic mixture of $4^1/_2$ per cent. This carbonaceous film does three things essential in welding. It prevents oxidation and reduces oxides. It promotes intimate contact by acting as a flux and causing the molten metal to run out over the melted surface. It acts as a temperature indicator denoting by its formation the proper time to add weld metal.

Figs. 7, 8—Fuselages of Chromium-Molybdenum Tubing Are First Tack-Welded in Jigs

Fortunately from the standpoint of commercial feasibility, the carburizing agent is available in the standard oxyacetylene welding equipment by proper adjustment and manipulation of the flame. As a weld progresses, carbon is absorbed to a depth of one or two thousandths of an inch on the surface of the steel and melts spontaneously. The blowpipe is manipulated so that the carbonaceous film covers the base metal adjacent to the welding puddle.

This film has certain unique features. It is metallic. It is produced automatically. It melts spontaneously, and it disappears by dissolving into the weld metal as soon as its functions are fulfilled. The action may be termed "self-fluxing."

The process is known descriptively as excess acetylene welding. Considered in terms of its application to welding on chromium-molybdenum tubing, this process offers a number of advantages over the neutral flame method. It is faster. The indication of proper welding temperature by the spontaneous formation of the carbonaceous film permits more attention to be given to rod manipulation and the rod may be deposited more rapidly. Welding is carried on at a lower temperature. Figure 2 shows representative temperatures of various sections of a weld when this technique is employed.

The combination of faster welding and welding at a lower temperature reduces the tendency toward grain growth, as the time and the temperature at which the steel is held above the critical point are both reduced to a minimum. Reduced grain growth means improved physical properties.

The amount of expansion varies with the speed of welding. In general, the faster the weld the less the expansion that takes place, and the lower the resulting stresses. In general, a backhand technique will result in slightly less expansion stresses than a forehand technique. The excess acetylene welding process thus assists in overcoming expansion and contraction problems.

The carburizing or reducing atmosphere properly controlled by the excess acetylene flame tends to eliminate a decarburized surface on the tubing at the weld. The external supply of carbon tends to maintain the carbon in equilibrium in the steel, as it is not required to reduce the surface oxides. Carbon loss by migration is avoided.

This welding process reduces the probability of disturbing the chromium-manganese-carbon ratio of the steel immediately adjacent to the weld. The balanced composition proportioned to give optimum relationship between strength and ductility is maintained. When a suitable rod and the excess acetylene welding technique have been used, physical properties may be obtained by heat treatment equivalent to those of the original material. On fittings and small assemblies, heat treatment is desirable with the chromium-molybdenum steels. On larger assemblies it is often impracticable. In either case the excess acetylene welding process assists in obtaining better welds.

Still another item might be mentioned. Due to the semi-automatic features of this process it can be used readily with either a forehand or backhand technique. The physical properties of chromium-molybdenum tubing in the normalized condition vary somewhat. Very light-walled tubing tends to cool rapidly and a higher tensile strength and lower ductility are obtained with the air-hardening properties of the steel. A backhand technique may be utilized to reduce the quenching effect where it is desirable to do so.

Fig. 9—Finish-Welding Is Accomplished in Wheeled Dollies. Single-Point Mounting Fore and Aft Permits the Entire Fuselage to Be Rotated as Desired

Fig. 10—A Bubble-Type Liquid Flux Dispenser Supplies Flux Automatically for Bronze-Welding Operations

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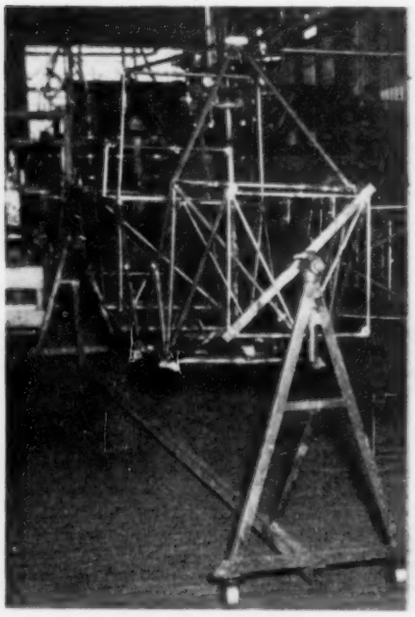

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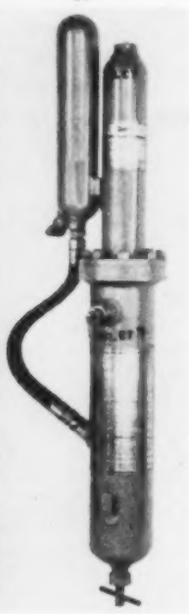


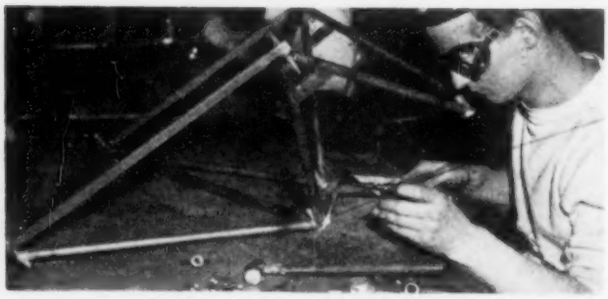


Fig. 11—This Motor Mount Is Fabricated by Welding Chromium-Molybdenum Tubing

Weld Applications

Up to this point we have discussed, at some length, the basic problems and metallurgy of welding chromium-molybdenum tubing by the oxyacetylene process. This is because the greatest amount of welding is done on this material. In our plant, we use about 85 different sizes of tubing ranging from $^1/_4$ inch to 2 inch in diameter. Wall thicknesses vary from $^1/_{64}$ inch to $^1/_8$ inch. Stock tubing, received in lengths of from 12 to 20 ft., is cut to size and then shaped for assembly.

At this stage of production, welding is encountered for the first time. The various jigs used for holding the tubing during the shaping operations are fabricated in the tool department by bronze-welding, a process which is particularly effective for this type of work because of its great flexibility and speed. Figure 3 shows a small group of the more than 400 jigs used in shaping the tubing before assembly. Figure 4 shows one of the jigs in use while forming the ends of a tubular member.

From this point, the various tubular members are transported to the adjacent fuselage and bench welding departments for fabrication into component aircraft parts. Manifolded oxygen and generated acetylene are supplied through a piping system which terminates in a number of strategically located drop rings similar to the one shown in Fig. 5. These drops provide at present for a total of 124 separate welding stations, all of which are so positioned as to provide a maximum effective working range for each operator. In addition, the method of suspension from above conserves valuable unobstructed floor space all the way along the line.

In the fuselage department the shaped sections of tubing are first set up in jigs for tack welding. General views of this stage of construction are shown in Figs. 6, 7 and 8. The jigs are of reasonably heavy, rigid construction and were designed along three basic principles: (1) they provide for exact positioning of the tubular members and for clamping them in place until they are joined; (2) wherever there is a possibility of unfavorable warpage taking place, provision is made for keeping the body of the metal cool during welding; and yet (3) their construction is such as to prevent the edges to be joined from becoming unduly chilled.

On completion of the tack-welding operations, the fuselages are mounted fore and aft in wheeled dollies like that shown in Fig. 9, and passed along to the finish-welding section of the fuselage department. Here all tack welds are finished by experienced operators. Their task is facilitated by rotating the entire fuselage in the dolly in order to take advantage of the best possible welding position for each joint.

The total number of steel welds in clusters, fittings and turtle decks in a given airplane varies according to the model, but the average number is close to 150. Additional bronze welds for some of the smaller fittings, guides for control cables and other similar parts average over 200. In these latter operations, production has been considerably speeded by use of the vapor flux dispenser shown in Fig. 10.

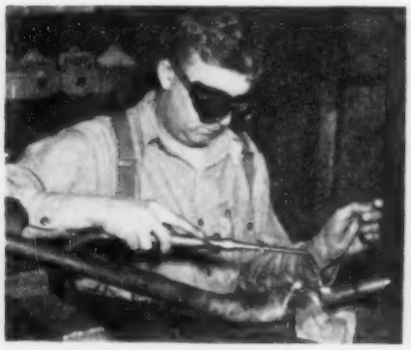


Fig. 12—Here an Axle Assembly for the Landing Gear Is Being Welded

Fig. 13—This Wing Compression Web Is in the Finish-Welding Stage

Fig. 14—Here a Stainless Steel Exhaust Manifold Is Being Assembled by Oxyacetylene Welding

Fig. 15—This Muffler, Being Welded, Is Made of Stainless Steel

Automatic Flux for Bronze Welding

This piece of equipment is connected between the regulator or hydraulic back-pressure valve and the blowpipe so that all of the acetylene used passes through the dispenser. The acetylene, as it flows toward the blowpipe, bubbles through a special liquid flux within the dispenser and picks up the required amount of flux in vapor form. The vapor flux then passes through the hose and blowpipe directly to the point of welding where the required fluxing is produced upon the parts being joined. Application of the flux is thus automatically and mechanically controlled. Only the required amount of flux is deposited at the exact point where it is needed so that waste, due to excessive use of flux, is eliminated, and sound bronze welds of excellent appearance are speedily obtained.

Bench-Welding Applications

As the fuselages are being constructed, the bench-welding department is busy fabricating fittings and hundreds of small assemblies. The necessary operations here include fusion welding of chromium-molybdenum and stainless steel, and bronze welding. The operator in Fig. 12 is welding a chromium-molybdenum steel axle assembly for the landing gear. Other parts welded from this material include motor supports (Fig. 11), control-stick torque tubes, fire-wall supports, wing compression webs (Fig. 13), tail-surface assemblies, including elevators, rudders, fins and stabilizers, bell-crank brackets and many other parts. Stainless steel welding on present models is confined to mufflers (Fig. 15), auxiliary fuel tanks and exhaust manifolds (Fig. 14).

Our assembly operations, in a plant with an area of 140,000 sq. ft., cannot be called strictly straight-line because two floors are used. However, major assemblies are moved through the shop by means of an overhead conveyor system which terminates in the final assembly department and our layout is organized so that all assemblies, subassemblies and single parts arrive in the various departments at the precise moment to insure smooth production. Our potential capacity is about 600 planes a month.

Conclusion

In summarizing, it would seem that welded tubular design at the present moment is still the most satisfactory method of construction for light airplanes. In fabrication of component parts from the widely employed chromium-molybdenum tubing, welding by the excess acetylene method has largely supplanted fusion welding by the neutral flame for several important reasons. The excess acetylene method is faster and it permits more attention to be given to rod manipulation. Welding is carried on at a lower temperature, thereby resulting in reduced grain growth with corresponding improved physical properties in the weld. Because the newer process is adaptable to either the forehand or the backhand technique, it can assist materially in overcoming expansion and contraction problems. Finally, the carburizing or reducing atmosphere of the excess acetylene flame tends to eliminate decarburized surface on the tubing at the weld.

A second important aid in speeding the production of light planes is the vapor flux dispenser previously described. This piece of apparatus makes fluxing for bronze welding completely automatic by mechanically delivering the exact amount of flux at the actual point of welding and at the precise moment it is needed, thus greatly eliminating the human element in this respect. The regular results are bronze welds speedily made and which are uniformly sound and of excellent appearance.

Discussion of "Flame Machining-Control and Applications"*

By John J. Crowe†

For an excellent paper well presented I want to compliment both Mr. George L. Walker from whom I learned much of the little I know about cutting and Mr. W. G. Sylvester to whom he is now handing on information gained through many years of experience.

Flame Machining is not new, we have been doing it in this country for thirty-five years but the particular type of flame machining covered by this paper is comparatively new and up until recently was applied in a haphazard manner.

This paper has to a large extent reduced the art of flame machining to a science, and it is now possible to tool up a job for flame machining much the same as we would tool up for a machine tool operation.

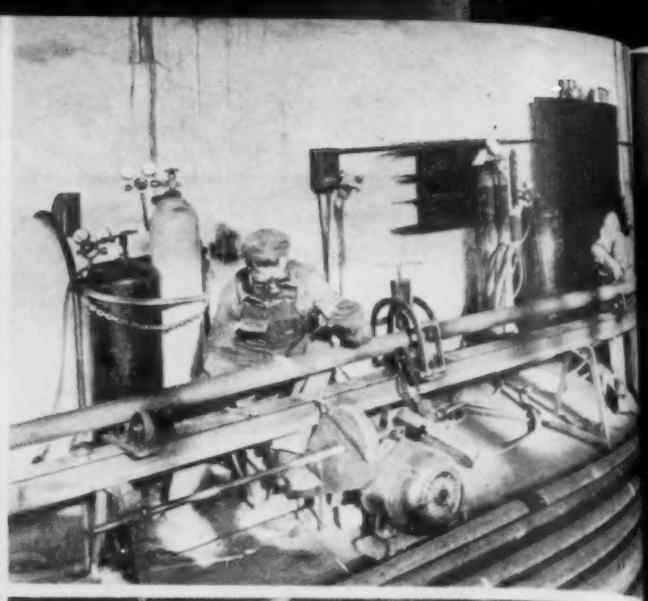
Thirty-five years ago when the cutting torch was first introduced in this country—machine tools would remove as much as $^1/_2$ lb. of metal per minute and there are now machine tools available that will remove as much as twenty pounds per minute, but compare the performance of these modern machine tools with the oxygen-acetylene cutting torch and we find that the power requirements of the machine tool may be one-thousand times the power required to operate the torches necessary to remove the equivalent amount of metal and the cost of the oxyacetylene equipment is only about one hundredth of that of the modern machine tool.

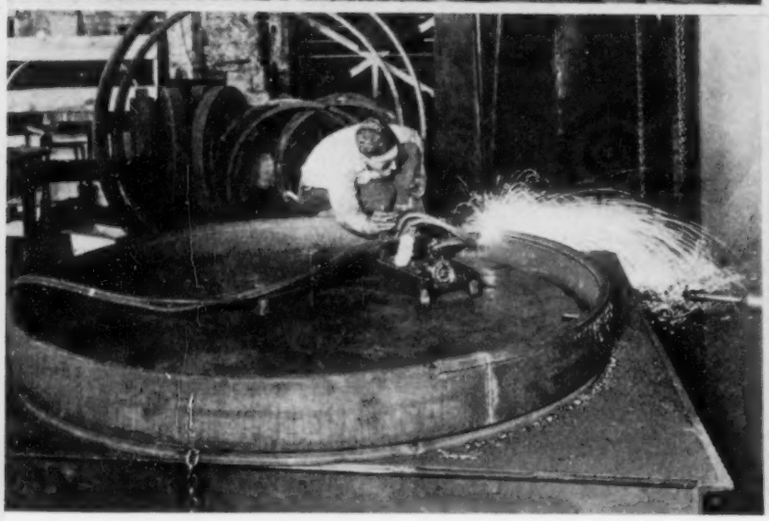
With the developments that have been made in the control of flame machining the old obsolete machine tools of thirty-five years ago may now be fitted with oxy-acetylene cutting torches and used to compete with the best of the modern machine tools for many rough machining operations.

Another important point that will bear emphasizing is that the light oxyacetylene equipment may be readily transported to the job whereas when the modern machine tool is used the work must be brought to the tool and this latter operation may be surrounded with difficulties.

* Paper by Walker and Sylvester presented at Annual Meeting A. W. S., Cleveland, Oct. 1940 and published in Feb. 1941 issue of THE WELDING JOURNAL.

† Assistant to Vice-President, Air Reduction Sales Co., New York.





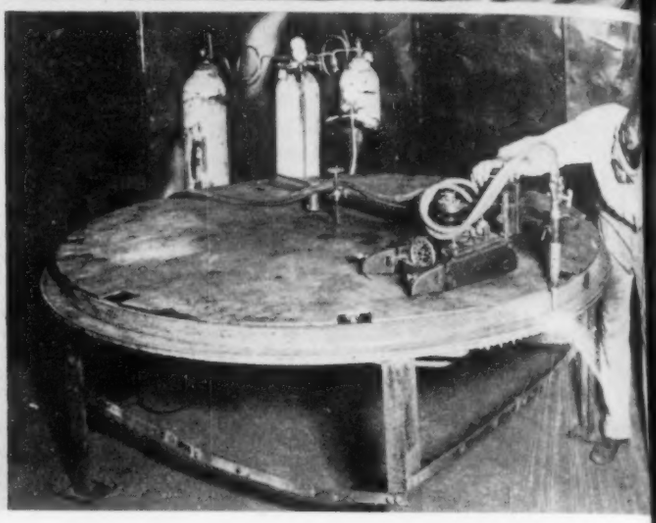


Fig. 1 (Upper Left)—This Rotary Dryer Makes More Than a Carload of Welded Stainless Clad Plate. All Joints Are Butt Strapped and All Inside Welding Is Done with Stainless Steel

Fig. 2 (Upper Right)—On This Revolving Jig Steam Tubes Up to 60 Feet Long Are Made from Standard Mill Lengths

Fig. 3 (Lower Left)—Cutting a Bar Ring to Width with the Radiagraph

Fig. 4 (Lower Right)—Using the Radiagraph to Bevel Cut and Angle Ring in Preparation for Arc Welding. The Cutting Flame Replaces a Boring Mill Operation and Makes a Substantial Saving

Fabrication of Rotary Dryers

By C. E. Bill*

AS THE development of machine gas cutting, oxy-acetylene and arc welding techniques over the past ten or fifteen years has benefited so many industrial fabrication processes both large and small, lowering costs and improving quality, so has this development benefited businesses like ours that have rather peculiar production problems. These problems are peculiar in that they result from the necessity of building a comparatively small quantity of heavy units, each individually designed and fabricated to fit a particular production process or problem of the customer.

It is amazing even to those whose daily work is confined to the solution of drying problems to contemplate the vast number of industrial processes that involve drying, either as a step in the process of manufacture of the finished main product or as a means of putting a waste or by-product into a marketable condition.

The variety of the methods that must be applied for the successful and economical solution of various problems and the importance of careful design of even the smallest details of the machinery to adapt it to the chemical, physical and mechanical properties of the various materials to be dried, make extreme flexibility of fabricating methods of utmost importance.

As we go back to the old days of the hack saw, hammer and forge we wonder how machinery like ours was fabricated at all in those times. The answer of course is that without the present modern aids, problems of fabrication that can now be approached with confidence that a simple solution will be readily found, would not even have been considered possible of solution in the horse and buggy era.

The Louisville Drying Machinery Company early recognized the value of the new technique of fabrication and has constantly striven to apply and improve the modern methods as fast as possible. A few examples are illustrated to bring out the variety of operations and the need for flexibility of design in the production of equipment for drying operations.

The large rotary dryer shown in Fig. 1 is fabricated from $^3/_8$-inch stainless clad plate. The interesting thing

* Sales Engineer, Louisville Drying Machinery Co., Inc., Louisville, Kentucky.

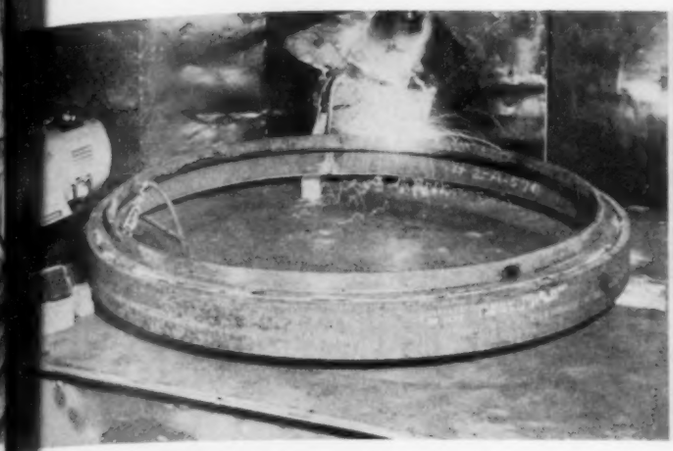
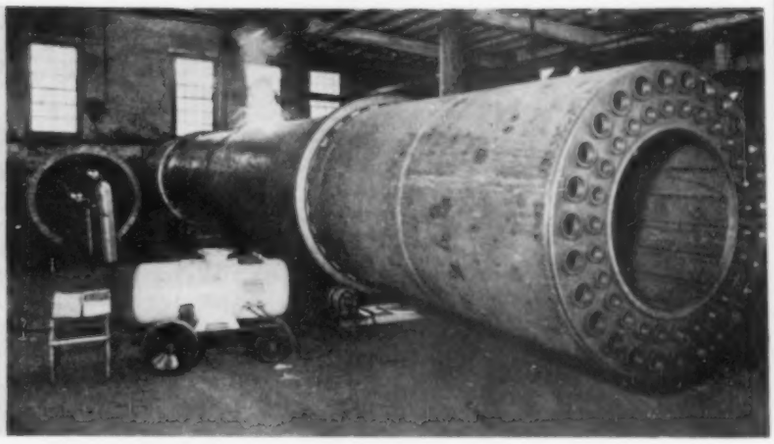


Fig. 5—A Heavy Angle Bar Ring in the Process of Arc Welding, After Shaping and Edge Preparation by the Radiagraph



Photos courtesy Air Reduction Sales Co. and Wilson Welder and Metals Co., Inc.

Fig. 6—Applying the Final Weld Bead to the Outside of a Steam Tube Dryer Cylinder

about this shell is the fact that both the longitudinal and circumferential joints were made by using $^1/_2$ x 4-inch steel butt straps plug welded and fillet welded to the shell plates which had been straight sheared and closely butted. These joints are finished by a stainless steel seal weld on the inside of the cylinder. The stainless steel lifters or flights, of which there are 400 inside the cylinder, were of special design supported on special stainless steel bolts passing through the shell and arc welded to the flights.

Figure 2 shows operators welding steam tubes in a Louisville Rotary Steam Tube Dryer. The work is set up in a revolving jig and the rotation of the work is controlled by a foot switch. An $^1/_8$-inch alloy rod is used for filler. Tubes of any length up to 60 feet long are thus fabricated from lap welded or seamless drawn steel tubing bought in 20-foot lengths. Seamless drawn aluminum tubes are also used for some dryers, lengths greater than 50 feet being formed by joining shorter sections by oxyacetylene welding. Tubes of nickel chrome alloy are fabricated by atomic hydrogen arc welding and tubes of monel metal and nickel by oxyacetylene welding or arc welding.

In the remaining photographs the combined utility of the mechanically operated oxyacetylene cutting torch and the arc welding machines for fabricating subassemblies is portrayed.

Future High-Speed Construction Hinted in New Georgia Home

By A. F. Davis*

NEW building construction speed, which permits erection of factories, plants, homes and other structures in half the time of conventional methods, and which would be a vital aid in speeding present defense building requirements, is recorded in completion of a new 7-room residence in Georgia in less than two months.

This home (see Figs. 1 and 2), built for Mr. and Mrs. R. G. Le Tourneau, $^1/_4$ mile from the new Le Tourneau plant at Toccoa, Georgia, utilizes a new type of prefabricated arc-welded steel "building block," or panel, which entirely revolutionizes all ideas of structural practice by completely eliminating the usual framework. Applicable to any structure, this "building block" is framework and wall member in one unit. Because of this simplicity, building construction time is reduced by as much as 50%.

These steel "building blocks," (see Fig. 3), used in the new Le Tourneau home, also in all the buildings of the new $3,000,000 Le Tourneau project at Toccoa, are 7 feet 8 inches long by 3 feet 10 inches wide by 6 inches thick for walls and 18 inches for roof. Panels are formed by pressure stamping of 12-gauge steel sheets, which are welded together with interior spacers set at intervals of not more than 24 inches to form a stout, box-like double panel member. In home construction, these panels completely eliminate conventional stud and joist framework.

Fig. 1—Front View of New Arc-Welded Steel Le Tourneau Home Built in Georgia in Less Than Two Months

* Vice-President, The Lincoln Electric Company, 12818 Coit Road, Cleveland, Ohio.

Fig. 2—Le Tourneau Home from Living Room Side

In larger structures, they do away with columns and roof beams. Because they are field welded together by continuous welds, both inside and out, they form unusually rigid and fireproof construction. They can be welded together to suit any design or arrangement

Advantages claimed for arc-welded steel panel construction, in addition to high-speed construction, include: security against termites, weathering, fire, tornado, cyclone, storm and flood (a house of similar construction was floated across the Illinois River to the Le Tourneau employees' home site); initial low cost; flexibility in design.

Planned, built, decorated and furnished, largely under the personal supervision of Mrs. Le Tourneau, the new home is 43 feet 8 inches wide by 70 feet deep. It has 1 master bedroom, 12 feet 9 inches by 11 feet 1 inch; 1 guest bedroom, 15 feet 4 inches by 11 feet 1 inch; 1 bedroom, 11 feet 5 inches by 11 feet 2 inches; and a fourth bedroom, 11 feet 2 inches by 11 feet 6 inches; 1 maid's room, 11 feet 2 inches by 7 feet 7 inches; 2 baths; living room and connecting dining room, the former 15 feet by 26 feet 9 inches and the latter 18 feet 9 inches by 15 feet 9 inches; kitchen and connecting breakfast room, 18 feet 9 inches by 11 feet 1 inch; utility room, 11 feet 5 inches by 7 feet 5 inches; laundry room, 10 feet 5 inches by 9 feet; and a furnace room, 9 feet 2 inches by 6 feet 7 inches. At the front there is a patio, 15 feet 4 inches wide by 11 feet 11 inches deep, recessed 7 feet 11 inches; also a side patio, completely recessed, 18 feet 2 inches by 12 feet.

Arrangement.—From inside at front looking toward rear along left-hand side is the guest bedroom with closet, then bath, then master bedroom with closet, then another bedroom. Along rear from last-mentioned bedroom is a connecting bath, then maid's room, then an L to the utility room at right rear corner. Along right side, starting at front, we find the living room, then side patio, then bedroom. In center, from front to rear are: first, the dining room, then kitchen-breakfast room, and behind that the furnace room and laundry.

Insulation is with Vermiculite, a Le Tourneau mineral product, inside the panels. Floor is of concrete. Ducts are 12-gauge copper-bearing arc welded steel. There is a combination heating, (hot air pressure), and cooling, (water) system. Glass brick is used in the alcove of the living room with large windows opening on the patios. Sink and kitchen cabinets are of steel.

Making possible a record feat in constructing the Le Tourneau home and proved particularly applicable to industrial structures by its use on the Toccoa project, it is believed that arc welded design and erection would be tremendously helpful in meeting emergency needs for factory additions and the many other miscellaneous structures required in the Defense Program.

Fig. 3—New Structural "Building Block," a Wall-Frame Structural Unit Fabricated by Arc Welding for Le Tourneau Home Construction

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(*Continued on page 211*)

Welding Society

ACTIVITIES — Related Events

PRESIDENT'S MESSAGE

Judging from the condition of the Society's membership our Sections are being successful in carrying out their local programs. Some are eminently successful and are engaged in educational programs of great value to their local industries. Those responsible for local activities are now studying the problems of next year's operations.

The dislocation of industry incidental to the development of the National Defense industry brings numerous problems to the local sections. There is a shortage of engineers experienced in the design of welded structures and in the organization of production methods. This shortage requires the dilution of our engineers and the assignment of greater responsibility upon those not fully trained by education and experience.

A number of our educational institutions are organizing special programs for training of design, production and inspection personnel. The popularity of such programs indicates that they fill a distinct need.

All this organized effort does not lessen the opportunity of our local sections in helping the personnel of their local industries to obtain a better knowledge of the principles and art of welding and of designing welded structures. There is a wealth of experience of others who have pioneered in various branches of welding which is available to local groups for the asking. This experience is not available in the literature. But more important than the importing of knowledge is the inspiration given by leaders through personal contact and acquaintance.

Those who organize such local activities deserve and will possess the personal satisfaction that comes not only from assisting our fellows in improving themselves but also that which comes from assistance to our National Defense.

Such are the opportunities of service.

AIRCRAFT STEEL WELDING PRIZE CONTEST

The Summerill Tubing Company, Bridgeport, Pa., is establishing a series of prizes to be awarded by the AMERICAN WELDING SOCIETY at its annual meeting during October 1941 for papers to advance the art of welding of aircraft steels, including tubing and other steel parts for tubular assemblies.

Conditions

There will be awarded the following prizes provided that papers submitted are judged worthy of award: One $300 prize, one $200 prize and additional prizes totalling $100 to be distributed for such additional papers as the Committee of Awards may direct.

The papers may treat of any type of welding which is or can be used for the fabrication of structures or assemblies in the production of aircraft steels such as 1025, X4130, X4135, X4340 or similar steels. They may cover any phase of the problem whether concerning joint design, fabrication or laboratory investigations.

The contest is open to any resident of this country without restriction.

Papers must be submitted not later than August 18, 1941, to the Aircraft Welding Contest, AMERICAN WELDING SOCIETY, 33 West 39th Street, New York.

The Committee of Awards of the AMERICAN WELDING SOCIETY, with the addition of two men associated with the aircraft industry, will constitute the judges. The decision of the judges will be final.

Papers submitted in the contest may, at the discretion of the AMERICAN WELDING SOCIETY, be included in its next annual program or be published in THE WELDING JOURNAL.

All papers must be typewritten, single spaced, written on one side only of blank white paper. Photographs, charts, graphs, etc., may either be attached directly to the copy or may be detached, in which case they should be clearly identified.

TENTATIVE PROGRAM FOR FIRST NEW ENGLAND WELDING CONFERENCE

Sponsored by Boston Section of A. W. S. to be Held at Massachusetts Institute of Technology, April 25 and 26, 1941.

Friday, April 25th

9:00 A.M. Registration
9:45 A.M. Address of Welcome
10:00 A.M. Technical Session
Flame Cutting
Weldability of Steels
12:30 P.M. Luncheon
2:00 P.M. Technical Session
Copper and Brass Welding
Welding in Machine Design
6:00 P.M. Conference Dinner

Saturday, April 26th

9:00 A.M. Registration
10:00 A.M. Technical Session
Resistance Welding
Welding Steel Structures
12:30 P.M. Luncheon
2:00 P.M. Technical Session
Inspection of Welds
Qualification of Welders
5:00 P.M. Adjournment

For further information write Professor Peter E. Kyle, Chairman, Massachusetts Institute of Technology, Cambridge, Massachusetts.

FUTURE MEETINGS OF SOCIETIES

American Chemical Society. April 7–11, 1941, St. Louis, Mo.

American Institute of Chemical Engineers. Semi-annual meeting, May 19–21, 1941, Chicago, Ill.

American Railway Engineering Association. Annual meeting, March 11–13, 1941, Chicago, Ill.

American Society for Testing Materials. Spring meeting, March 3–7, 1941, Washington, D. C. Annual Meeting, June 23 to 27, 1941, Palmer House, Chicago.

American Society of Civil Engineers. Spring meeting, April 23–25, 1941, Baltimore, Md.

American Society of Mechanical Engineers. Spring meeting, April 1–3, 1941, Atlanta, Ga.

Electrochemical Society. Spring meeting, April 16–19, 1941, Cleveland, Ohio.

Midwest Power Conference. April 9–10, 1941, Chicago, Ill.

National Electrical Manufacturers Association. May 11–15, 1941, Hot Springs, Va.

Western Metal Congress and Exposition. Los Angeles, Calif., May 19 to 23, 1941.

American Welding Society, Annual Meeting, October 20 to 24, 1941, Bellevue-Stratford Hotel, Philadelphia.

BATTELLE MEMORIAL INSTITUTE—RESEARCH ASSOCIATES 1941–1942

Further appointments of Research Associates are to be made at Battelle Memorial Institute, Columbus, Ohio. Young men who are university or college graduates and who have shown exceptional aptitude for research, either in graduate work or in a brief industrial experience, are eligible. Preference will be given to those who have majored in physics, physical chemistry, organic chemistry, chemical engineering, metallurgy, fuels or ceramics, and especially to those who have completed their Ph.D. training and are pointed toward a career in industrial research.

The Research Associates are brought together for a year's experience at the Institute to help bridge the gap between their academic training and their future industrial research work. The purpose is to develop highly trained research men for industry.

An appointment as Research Associate is for one year, including vacation, and may be extended for a second year. The salary is $1800. Research Associates work full time on approved research projects under the supervision of the Battelle technical staff. The projects assigned are fundamental or general ones, leading to the publication of information that will be useful to science and industry.

Applications should be submitted not later than April 1, 1941.

Application forms and further information may be secured by writing to Clyde E. Williams, Director.

EMERGENCY STANDARDS

The American Standards Association today announced adoption of a special method for quick action in developing Emergency Standards needed for defense purposes. This method will make it possible to turn out standards for parts and materials used in defense production as rapidly as is consistent with a good technical job.

In the words of the committee drawing up this streamlined procedure, "It is highly desirable that the American Standards Association be prepared to act promptly on requests for the preparation of standards for use in the National Defense Program. In order that such requests can be met with the speed that is essential, it is obviously necessary to greatly abbreviate the normal procedure of the Association."

The Emergency Procedure will empower special committees to act for the Association in starting new work, appointing Technical Committees, and in approving Emergency Standards.

The rôle that industrial standards play in peacetime production is greatly increased in time of national emergency like the present. This is because standards are a key factor in every program of large-scale production. Every government order is based upon specifications or standards; and as a single order frequently extends to hundreds of companies—manufacturers of parts and suppliers of materials—each company must control its operations closely so that the completed product will comply with the standards originally laid down in the order. Shortcomings in the original standards—obsolete requirements—unnecessarily close fits—faults in workmanship or materials—or difficulties in the way in which the standards are applied by the manufacturer, all result in bottlenecks which cut down the flow of aircraft, blankets, trucks, etc. from the factories.

All Emergency Standards will be published in a distinctive format that cannot be confused with regular American Standards. After the emergency has passed, the newly adopted procedure provides that "the Defense Emergency Standards will be reviewed by the appropriate committees, and approved, amended, or withdrawn, through the regular procedures of the Association."

Among the defense jobs on which the American Standards Association is already working are: Tool Steels, Screw Threads, Bolts and Nuts and Wrench Head Openings, Machine Pins, Wire and Sheet Metal Gages, Mechanical Fits, Statistical Methods of Quality Control in Mass Production. Many of its safety code projects are also important in providing protection for workmen on defense production jobs.

TECHNICAL EDITORS NEEDED BY WAR DEPARTMENT

In connection with its defense work the War Department is in need of technical editors to perform various writing duties, and prepare for publication technical manuscripts and reports. The work will be confined largely to the fields of engineering, chemistry and physics. The salaries of the positions are $2600 a year for Assistant Technical Editor, and $3200 a year for Associate Technical Editor. To fill the positions the U. S. Civil Service Commission has announced an open competitive examination.

Applicants will not be given a written test, but will be rated on their education and experience and on corroborative evidence. They must have completed a 4-year college course with major study in

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EACH CAN SAY

"I WAS A CLERK"

"I WAS A LINEMAN"

"I WAS A DRAFTSMAN"

THIRTY-SEVEN years ago, in 1904, the president of the American Telephone and Telegraph Company went to work as a clerk in one of the Bell System companies.

About that time, the 18 men who are now the presidents of the Bell telephone companies were starting their careers. For, like the head of the System, they have worked many years in the business — an average of 38 years each. Each of them can say: "I was a clerk," "I was a lineman," "I was a draftsman"— and so on.

The "know how" is here — for the every-day job of running the telephone business or to serve you in emergency. Up-from-the-ranks management is doubly important these days.

THE BELL SYSTEM IS DOING ITS PART IN THE COUNTRY'S PROGRAM OF NATIONAL DEFENSE.

BELL TELEPHONE SYSTEM

engineering, physics, or chemistry, and in addition must have had experience in the writing or editing of technical material in one or more of these fields. Persons who have not completed the full 4-year college course may substitute appropriate professional experience for not more than 2 years of this requirement. Graduate study in scientific fields may be substituted for part of the writing experience.

Further information and application forms may be obtained from the Secretary of the Board of U. S. Civil Service Examiners at any first- or second-class post office, or from the U. S. Civil Service Commission, Washington, D. C.

ANNUAL CONVENTION OF I.A.A. IS POSTPONED

Announcement has just been made that the 41st Annual Convention of the International Acetylene Association, originally scheduled to be held at the Hotel Netherland Plaza in Cincinnati, Ohio, on April 2nd, 3rd and 4th has been indefinitely postponed. The action by the Association's Board of Directors has been taken because of the increasing demands upon the time of engineering personnel in the Industry, and the growing feeling that technical and other manpower, normally applied to Convention activities, should be released for work more urgent under today's conditions.

Cancellation of arrangements already made and abandonment of all plans for the April Convention will in no way affect any future Convention or other Association activities. It is generally agreed that conventions of the type held during the last several years are important and valuable not only to members of the International Acetylene Association and the oxyacetylene industry, but to the technical public as well. At this time, however, it is believed that the Association can best serve by leaving its members free to devote their undivided attention to the most urgent of today's great national and industrial problems.

EWERTZ TO BUILD U-BOATS IN WEST

Eric H. Ewertz expects for the next five years or so to be a resident of Manitowoc, Wis. On the shores of Lake Michigan, nearly 1000 miles from the open sea, he is to supervise the construction of the first ten submarines to be built inland.

As chief constructor at Elizabeth's old Crescent Shipyard, around the turn of the century, he had charge of building about eighty vessels, including the "Holland," first successful submarine, and six others. There, under his supervision, the first pneumatic tools were tested out; the first smokeless powder machinery and testing guns were built, and experiments were carried out with the one-man torpedo, as well as the field guns for firing dynamite charges.

From 1918 to 1928, Mr. Ewertz was general manager of the Moore plant of the Bethlehem Shipbuilding Company, in Elizabeth. Here, in addition to ship construction, he produced machinery for oil refineries, ship deck machinery, all types of pumps, steam turbines, Diesel engines, oil-burning equipment and general machine and foundry work.

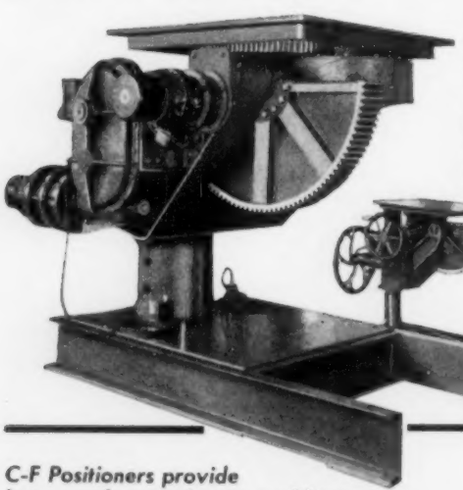
For several years Mr. Ewertz conducted his own consulting welding engineering practice in New York City, further promoting and developing fusion welding in ship construction, steel structures and storage tanks, and rendering assistance in redesigning and surveying.

In his present capacity, as consulting engineer for the Electric Boat Company, of Groton, Conn., Mr. Ewertz will assume charge of the construction of ten of the thirty-five submarines which that company is under contract to build for the United States Government. The other twenty-five are being built at Groton. Six more will be constructed in United States Navy yards.

Explaining that the Groton concern was the only shipyard equipped to build submarines, Mr. Ewertz said that since its capacity is only twenty-five, it was necessary to find another yard in which the remaining ten could be built.

It was found that the Manitowoc Shipbuilding Company could construct ten submarines by making certain additions to their plant, and that the labor market there was suitable for such an undertaking.

FOUR SIZES of hand and power-operated C-F Positioners provide capacities from 1200 to 14000 lbs.



- Tables tilt 135°, rotate 360°. Table height is adjustable. Table top is removable.
- Rotating and tilting movements are independent. Rotating drive may be constant or variable.
- The exclusive design of C-F Positioners permits a wide range of installation arrangements.

C-F Positioners provide better, safer, production welding.

Everyone concerned with welding knows that positioned welds, made down-hand are the best. Innumerable time studies also show these additional advantages of positioned welding: savings in welding time, cleaning time, overhead crane service and increased safety.

Write today for Bulletin WP-20 giving full information.

This circular, just off the press is an informative folder showing many examples of better and more economical welding with C-F Positioners.

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1307 S. KILBOURN AVE. CHICAGO, ILLINOIS

The Comptroller Says...
"Our own cost sheets show that Mallory's continuing investment in research and Welding Tip Standardization is paying us dividends."

No one has contributed more to the advancement and general economy of resistance welding than Mallory. It would be nearly impossible to name an industry that has not benefited tangibly both through the development of Mallory Alloys . . . and through the economies made possible through the standardization of welding electrodes.

Mallory's leadership has been based upon unremitting research and experimentation. Mallory's leadership will continue to be based upon this practical source of progress. When you specify Mallory Welding Electrodes, you may rely upon it that you are receiving the benefits of the most advanced knowledge of good welding practice.

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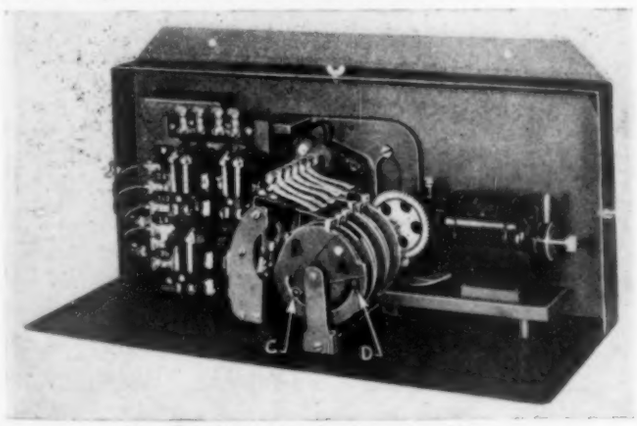
NATIONAL WELD-TIMERS are ALREADY doing a GRAND JOB on MANY NATIONAL DEFENSE PROJECTS

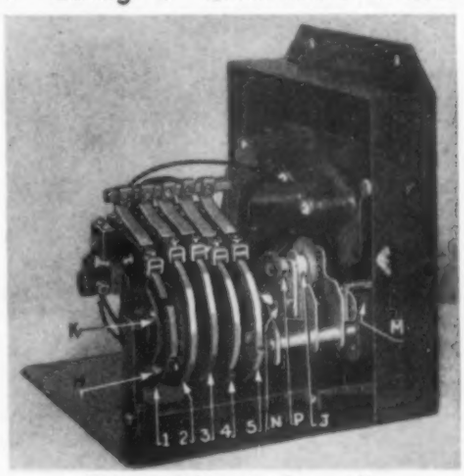
When Hiring Lots of NEW HELP, its Pretty Nice to have Weld Timers that are so SIMPLE TO OPERATE, and EASY TO UNDERSTAND

It makes Little Difference, for Spot Welding ordinary steel plate, ¼ inch thick, or that very flexible, Stainless Steel, "SKIN" stock, measuring .005" in thickness, there is a National Welding Timer, for EVERY PURPOSE.



No. 1800P Synchronous Timer for Alloys

Have You Written for Your Copy of Bulletin No. 146? Its NEW, and Full of Practical Information.



No. 1750P Timer for General Use

The National Type 1800P Timer at left, is specially adapted to control weld time for special alloys. It synchronizes with the A.C. sine curve, opening or closing on zero. Weld-time, as low as ½ cycle, or as much as 30 cycles, is obtainable.

The Type 1750P Timer is used extensively on Gun welders in the automotive body plants. Welding speeds as low as 30 spots per minute, or as high as 360 per minute, are possible.

NATIONAL TIME & SIGNAL CORPORATION

600 E. MILWAUKEE AVENUE **DETROIT, MICHIGAN**

"The Government gave the contract to that company, but wrote into it the stipulation that the ships must be built from the Electric Boat Company's plans and designs and under its supervision," Mr. Ewertz stated.

Accordingly, Mr. Ewertz went to Manitowoc last week to begin supervision of the work as the Electric Boat Company's representative, taking with him four men who are experts in their respective lines.

Twenty-three months is the shortest time in which a modern submarine can be built, Mr. Ewertz explained. Transporting each vessel from the Great Lakes to the sea will take another two months. Since the canals in the St. Lawrence River are not large enough to accommodate such craft, it has been planned to take them down the Mississippi to the Gulf of Mexico.

Tortuous Voyage Necessary

Great, floating drydocks, drawing six feet of water, will be built to convey the submarines on the tortuous voyage. Getting to the Mississippi via the Chicago Canal, they must be partly submerged to pass beneath Chicago's bridges. To go under one of the bridges, he explained, it will be necessary to submerge the vessels about three feet and to remove the periscope and periscope supports. Caissons then will be used to lift their keels above the shallow mud-flats, down the Drainage Canal to the Mississippi.

Upon their delivery at New Orleans, the craft will continue under their own power to Groton, there to undergo the required tests and trials. According to the plans, the ships will be built in groups of three, three and four. The first one, Mr. Ewertz said, probably will be delivered early in 1943, and from then on, deliveries will be made two to three months apart. He estimates that it will take about two months to complete the journey to the gulf, and for the towboat to return.

Explaining for the benefit of laymen some of the striking differences between the construction of submarines and of vessels designed to ply the surface of the water, Mr. Ewertz said:

"The whole construction is different, for a submarine is almost like two boats in one. It has what we call the outer hull and the inner hull. The machinery that goes into this boat is very complicated. That used on the surface of the water cannot be used under it. Each ship must have a battery to draw from when she runs submerged—a battery of 260 cells, each cell weighing a ton.

"The inside of a submarine is almost all machinery. While the interior is more spacious than the cramped quarters of submarines used in the first World War, there still isn't any space to spare. Considerable room must be reserved for the storage of spare parts. One hundred tons of bronze casting go into each boat, and miles upon miles of electric wires. Each boat is equipped with an indicating system, so that one may stand in the operating department and know that everything is closed when ready for submerging."

Mr. Ewertz's service to the United States Government during the first World War was one of the high lights of his accomplishments. In October 1917, the contract was signed for the building of the $15,000,000 Squanton plant and the construction of thirty-five destroyers, all to be built within twenty-seven months. Mr. Ewertz was placed in charge of this undertaking.

Four months after the breaking of ground, ship construction started and advanced as the plant grew. Seven thousand men were engaged in building the plant and the number of ship workers was gradually increased to about 9000, all in accordance with carefully developed procedure, permitting a mass production of ships and correspondingly low cost. In 1918, with thirteen months of the contract time spent, 65 per cent of the contract was finished.

Returning to Elizabeth in 1918 to take charge of the Moore plant, he was also in charge of all welding development for the Bethlehem Shipbuilding Company. He has been consulting engineer for the Electric Boat Company since 1934.

NEW HOPPER-TYPE TRAILERS

A new development in hauling equipment, in the form of an all-steel arc-welded hopper-type semi-trailer, was announced recently by the Landis Steel Construction Company of Picher, Oklahoma.

This unit, two of which can be seen in operation in the accompanying illustration, was developed primarily for efficient loading, transporting and dumping of gravel. Illustration shows units in the Tri-State mining field around Picher.

Of arc-welded construction, these trail-

Photo courtesy Lincoln Electric Co.

Two of the New Arc-Welded Steel 30-Ton Hopper-Type Semi-Trailers in Use Near Picher, Okla. for Hauling Gravel

Buy "Proven Fluxes" with Years of Guaranteed Satisfaction behind them
The Trade-Name is "ANTI-BORAX"

Ask for Them *Unequalled for Quality*

A Flux for every metal: Cast Iron Welding Flux No. 1; Brazing Flux No. 2; Braz-Cast Flux No. 4, for bronze-welding cast iron; "ABC" Aluminum Flux No. 8 for sheet Aluminum and all alloys of Aluminum; Stainless Steel Flux No. 9; Silver Solder Brazing Flux No. 10; "Anti-Borax" Tinning Compound No. 11.

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SHAWINIGAN CARBIDE

For
OXY-ACETYLENE WELDING AND CUTTING OF METALS

SHAWINIGAN PRODUCTS CORPORATION
EMPIRE STATE BUILDING
NEW YORK, N.Y.

None but the new VICTOR "AIRADIATOR" nozzle could complete this weld without overheating.

Why not make this test yourself? Any VICTOR distributor will gladly demonstrate.

Looks like a New Type Welding Nozzle—and it is!

Let's get rid of the water bucket to keep welding torch nozzles cool enough to function properly.

The new VICTOR "AIRADIATOR" nozzle will "keep a cool head" even when submerged in the deflected heat of confined space welding. The large radiating surface of multiple aluminum cooling fins prevents the "popping-hissing-backfiring" so annoying to the operator and so detrimental to sound welding. The "AIRADIATOR" nozzle was designed primarily for aeroplane parts welding but whether the operation involves the very light gauge metals, tubings, preheated castings or any weld positions which cause overheated nozzles, the "AIRADIATOR" nozzle is the answer.

You won't need water buckets to keep the "AIRADIATOR" nozzle cool.

VICTOR EQUIPMENT COMPANY

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SAN FRANCISCO

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LOS ANGELES

DISTRIBUTORS IN ALL PRINCIPAL CITIES

ers have hoppers fabricated of 8-gauge Mayari-R steel and all welding was done with shielded arc equipment.

Welded construction in heavy excavating and earth moving equipment is now standard with leading manufacturers This method is said to provide increased carrying capacity through maximum strength for least weight and of particular advantage, according to users, is the absence of projections on inner surfaces. This feature eliminates clogging and assures clean dumping of gravity-unloading equipment.

The new Landis trailer hauls 30 tons of gravel and the door openings in the hoppers are controlled directly from the cab of the truck. The two hopper doors may be operated simultaneously or individually.

MACHINE TOOLS

How the nation's machine tool industry is turning out lathes, milling machines, boring mills, planers and other types of machine tools for Uncle Sam's defense program at the rate of $650,000,000 a year, almost four times the production rate of the peak year of 1929, is told in a booklet entitled "Machine Tools" just published by the National Machine Tool Builders' Association, Cleveland.

The industry, the booklet states, has been training and employing new men so millions of dollars worth of new equipment as well as all existing equipment can be used night and day, and has doubled its employment in fifteen months.

The booklet describes the part that machine tools are playing in the national defense program and tells what machine tools are and what they do.

Featured in the booklet as illustrative of special purpose machines being built by the industry to speed up defense production is a 24-ton automatic machine for roughing out marine engine cylinders. Operating on six cylinders at one time, this new unit has cut machining time per part from 4 hours to less than 35 minutes.

100-TON WELDED TRUCK

From Portland, Oregon, comes word of a huge, all-welded, three-unit, 100-ton Cor-Ten steel truck built for the Bonneville Power Administration. The truck was fabricated with Chrome Copper welding electrodes by the Isaacson Company, builders.

The picture shows the truck with a test load of 108 tons. The purchaser plans to use it first to transport eight large 100-ton transformers from the railroad cars to the sub-station at Vancouver, Washington.

AN UP IN THE AIR JOB

Seventy-five feet above the surface of the Mississippi River, this operator is welding the sheet sections of 16-gage steel which were placed over the toll house of

Photo courtesy General Electric Co.

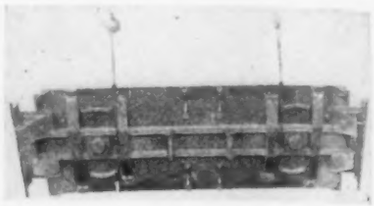
the $2,500,000 Centennial Bridge connecting the two cities of Rock Island and Davenport, Iowa. These steel sections were first attached to I-beams and the seams and bolt holes were sealed by welding.

DIESEL LOCOMOTIVE

Welding played an important part in the construction of a new 70-ton diesel-electric locomotive built at the Erie, Pa., works of the General Electric Company and now in switching service in the yards of the New York Central Railroad at Auburn, N. Y.

The platform is built up of steel members and plates fabricated entirely by welding. The cab is likewise welded throughout, with provision for easy accessibility to both engines and control. The truck frames are also completely fabricated by welding, using rolled carbon steel plates and shapes.

G E Diesel Electric Locomotive, 70-Ton, 400 HP



Oblique Bottom View Cab Underframe

The new locomotive embodies several unusual features. Double-reduction geared motors, flexibly mounted on the trucks, drive each axle. The power-plant rating is 400 horsepower, and the locomotive has a maximum speed of 25 miles per hour. Because of the double-reduction feature and the semiconstant-speed operation, the locomotive is particularly snappy with light loads, and is capable of handling a long string of cars if required. It is especially suited for operation in a small yard and has sufficient capacity, if required, for use in transfer service to other yards.

HIGH-PRESSURE STEAM LINES

Installation of high-pressure steam lines operating at 1300 pounds pressure and 900° F. total temperature has just been completed by the Dayton Power and Light Company at its Millers Ford Station, Dayton, Ohio. To withstand the high pressure and temperature it was necessary to use carbon molybdenum steel which has excellent physical properties and resistance to creep at high temperatures. In order to maintain these same physical properties in the welded joints, a shielded arc type of carbon steel electrode containing molybdenum in the coating was used. This electrode was selected after exhaustive tests by the Pittsburgh Piping and Equipment Co., which did the welding.

In welding the joints of this high-pressure steam line the base metal on either side adjacent to the weld was heated slowly to approximately 500° F. by means of electric resistance heater units and this temperature was maintained during the welding operation by enclosing these re-

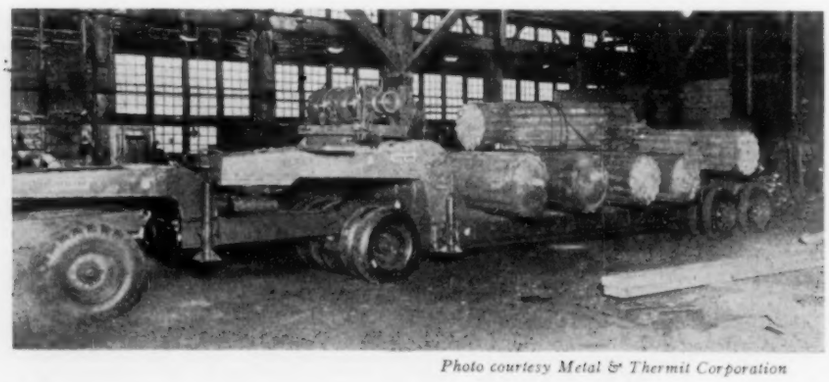


Photo courtesy Metal & Thermit Corporation

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You will find your local PAGE Distributor well able to give you exact recommendations—supplemented by interesting booklets—on the electrodes that will give you the production you expect and need today.

PAGE HI-TENSILE "F"—High speed welding, a shield-arc type electrode for vertical, horizontal or overhead.

PAGE HI-TENSILE "C"—A shield-arc type electrode for maximum strength, penetration and uniformity—vertical, horizontal or overhead welding.

PAGE-ALLEGHENY STAINLESS—Shield-arc type electrodes from which you can select one that will give you weld metal in welds that equals the stainless you weld.

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In Business for Your Safety

AMERICAN CHAIN & CABLE COMPANY, Inc.

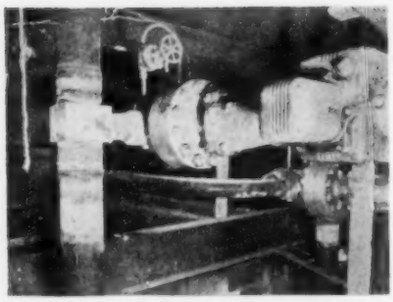


Photo courtesy General Electric Co.

Finished Joint in Carbon-Molybdenum Steel Pipe Arc Welded with High Tensile Electrode, Just After Removal of Asbestos Covering

sistance heater units in asbestos covering. After the weld was completed, an asbestos covering was also put over the welded joint in order to retard the cooling operation and obtain better grain structure. This method of preheating and then allowing the weld to cool slowly to room temperature reduces the temperature gradient between the molten weld metal and the adjacent base metal, thus preventing cracking and distortion of the weld and adjacent piping.

BOMB SCOOTERS

To scoot bombs from storage racks to planes and boost them aboardship, the government has ordered 600 bomb carriers like those shown here.

The carrier is placed under a bomb in the storage rack and pressure on a pedal hoists the bomb clear, after which it is lowered automatically, but gently, into carrying position. The carrier is then moved to the plane where a second push on the pedal boosts the bomb aboard.

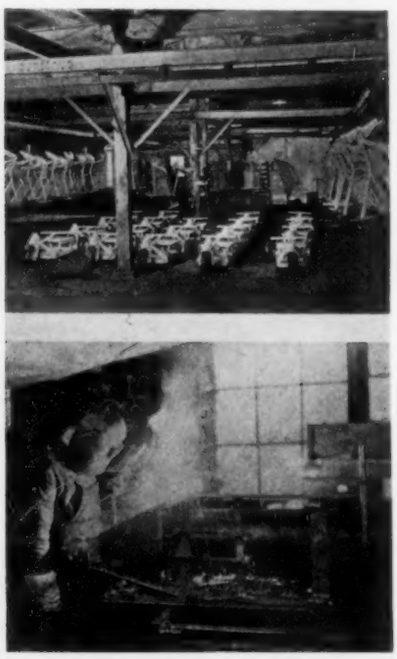
The manufacturers, Weaver Mfg. Co., Springfield, Illinois, say they were able to start production of these "bomb scooters" immediately after receiving the order because a new process of construction allows them to utilize the jack-lift principle employed in making their line of standard jacks.

With the new process, which is electric arc welding, the manufacturer builds these "scooters" simply by cutting up standard rolled steel parts, such as angles, plates and shapes, and fusing them directly together. Delays for pattern making and casting, also drilling, punching and heading up rivets, are entirely eliminated. As a result, this process permits fast production of equipment for National Defense.

Now being employed in construction of battleships, submarines, destroyers, military planes, guns, tanks and other essential items of National Defense, as well as vital machinery for Defense Production, welding is reported to speed production of finished products by at least 33 1/3%.

Figure 1 shows completed carriers while Fig. 2 illustrates fabrication of a carrier by arc welding.

Fig. 1—Part of an Order for 600 Arc-Welded Steel Bomb Carriers



Photos courtesy Lincoln Electric Co.

Fig. 2—Fabricating a Bomb Carrier at Weaver Mfg. Co., Springfield, Ill., by Arc Welding

BOOK ON TEMPERATURE—ITS MEASUREMEMT AND CONTROL

It was announced last year that a book on "Temperature—Its Measurement and Control in Science and Industry" was in preparation to make permanently available the valuable papers presented at a Symposium on this subject sponsored by the American Institute of Physics with the cooperation of the National Bureau of Standards and the National Research Council, held last winter in New York. This monumental volume will be ready for distribution about the middle of February. The original papers have been carefully edited by authorities in their fields. They have also been rearranged, supplemented and exhaustively indexed. All phases of temperature are covered in great detail. By special arrangement the book is to be published by the Reinhold Publishing Corporation, 330 West 42nd Street, New York City at a list price of $11.00 per copy. A valuable appendix of 25 reference tables is also included and this may be purchased separately bound for $1.00 per copy. With introductory material and indexes, the volume runs to 1375 pages. It will be especially valuable for chemists, teachers, physicists, biologists, medical men, metallurgists, geologists, electrical, mechanical and refrigerating engineers, and plant operating officials.

GOUGING AND DESEAMING

Gouging.—This new oxyacetylene process provides an inexpensive means for quickly and accurately removing a narrow strip of surface metal from steel plate, forgings and castings. Applications include the gouging of the underside of electric welds, the removal of weld metal, such as temporary tack-welds and defective welds, the grooving of plate edges in preparation for welding, and maintenance and scrapping operations. This operator is gouging bottom plates of an oil tanker for double-welded butt joints (Fig. 1).

Fig. 1

Deseaming.—The deseaming process, similar to gouging, is of great importance to steel mill operation, and is used for the removal of surface defects from slabs and billets. The nozzle of the deseaming blowpipe is designed to deliver, in conjunction with the oxyacetylene preheating flames, a relatively large jet of oxygen at low velocity, which "washes" away the defects (Fig. 2).

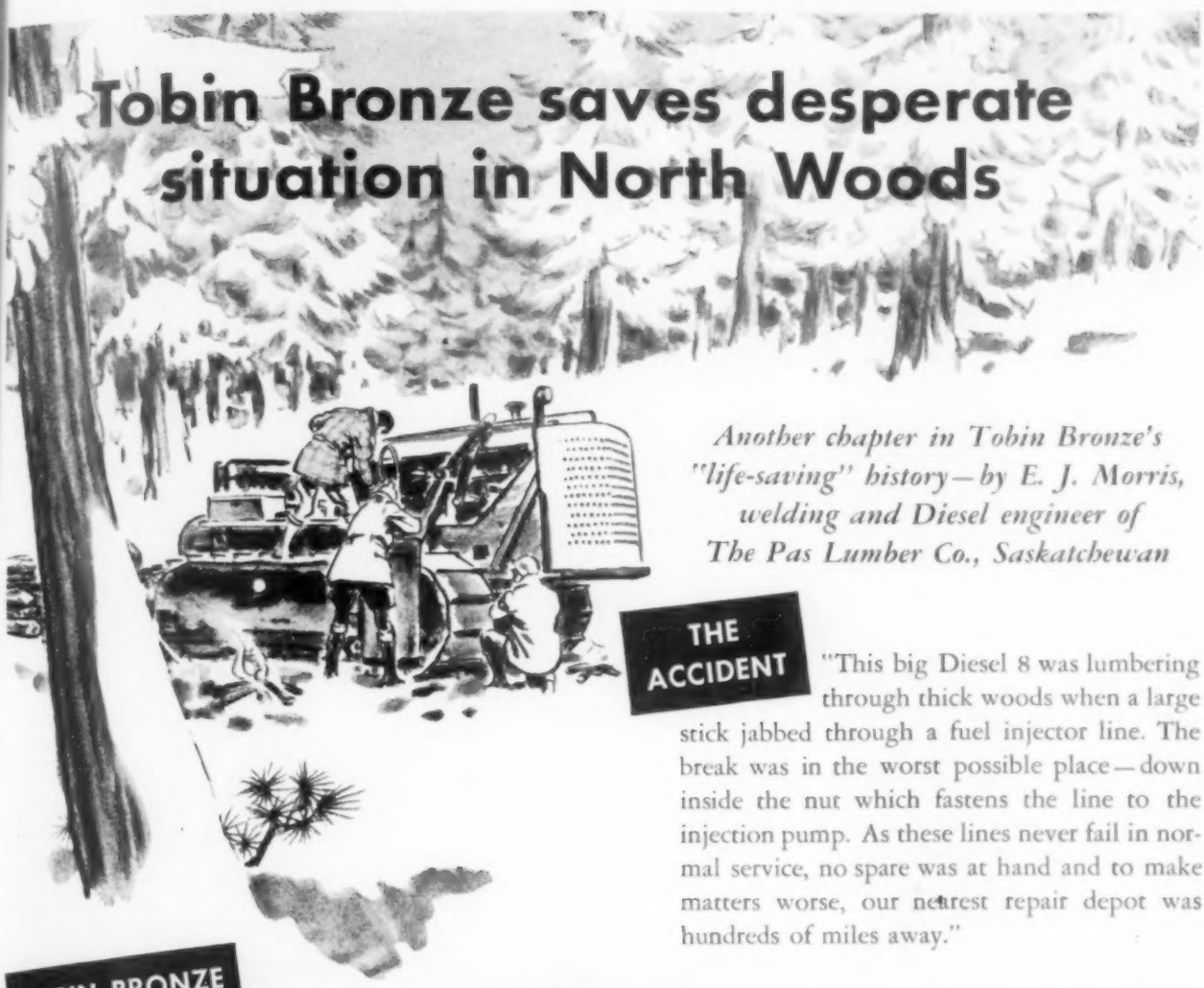
Photos courtesy The Linde Air Products Co.

Fig. 2

NEW PUBLICATION

The Foote Mineral Company announces the publication of the December 1940 issue of Foote-Prints which is available by addressing this company at 1609 Summer Street, Philadelphia, Penna. Of particular interest to the welding industry is the welding section featuring an article by J. C. Joublenc on iron oxide as an ingredient in welding electrode coatings. While primarily intended to discuss the function of iron oxide in electrode coatings, this article also stresses the importance of particle size control and points out the effect of particles size on slag viscosity.

Tobin Bronze saves desperate situation in North Woods



Another chapter in Tobin Bronze's "life-saving" history—by E. J. Morris, welding and Diesel engineer of The Pas Lumber Co., Saskatchewan

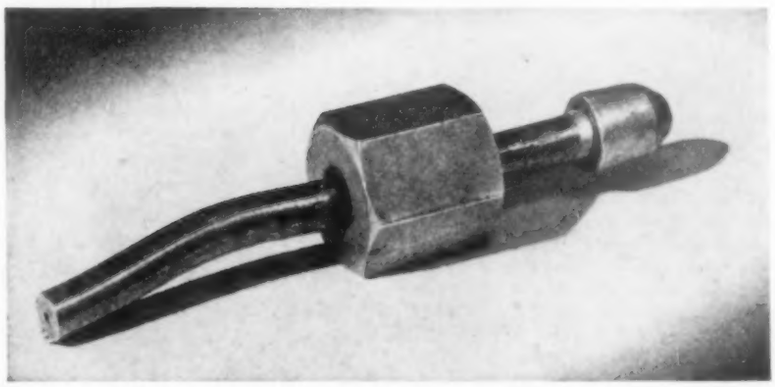
THE ACCIDENT

"This big Diesel 8 was lumbering through thick woods when a large stick jabbed through a fuel injector line. The break was in the worst possible place—down inside the nut which fastens the line to the injection pump. As these lines never fail in normal service, no spare was at hand and to make matters worse, our nearest repair depot was hundreds of miles away."

TOBIN BRONZE TO THE RESCUE

"We decided to try repairing the line with Tobin Bronze welding. In making the repair, the parts were ground cone shaped to allow almost complete penetration of bronze; alignment was secured by running a wire through the parts; and the weld made with Tobin Bronze. In about three hours, the machine was back at work and the welded line, which is subjected to pressures of 1800 to 2500 p.s.i., operated perfectly."

This is another instance proving the value of this Anaconda Welding Rod for difficult jobs on copper and copper alloys, steel and iron. Tobin Bronze carries the trade-mark "Tobin Bronze Reg. U. S. Pat. Off." in each rod. Look for this trade-mark and be sure you are getting the genuine. 39132



The new Anaconda 997 (Low Fuming) Welding Rod—high strength, tough weld metal with low fuming characteristics—is widely used for the general oxy-acetylene repair-welding of cast and malleable iron, steel and copper. Particularly valuable where repairs must be made quickly and easily on machinery parts, engine blocks, etc.

ANACONDA
from mine to consumer

Anaconda Welding Rods

THE AMERICAN BRASS COMPANY, General Offices: Waterbury, Connecticut

In Canada: Anaconda American Brass Ltd., New Toronto, Ont. • Subsidiary of Anaconda Copper Mining Company

NEW PRODUCTS

The Society assumes no responsibility for the validity of claims in this Section

TUBE DESIGN

New and old designs in G-E ignitron tubes for resistance welder control. Recognizing that appearance as well as utility is of great importance to the user, the General Electric Company, Schenectady, N. Y., has redesigned its ignitron tubes for resistance welder control. These tubes, which satisfied thousands of users in their former design, now have both inner and outer jackets of stainless steel and are completely corrosion resistant. The tubes are particularly adapted to welder control service because of their ability to carry very high peak currents for short periods.

This characteristic is essential in resistance welding control tubes, since resistance welding depends upon high currents to develop the necessary heat and the control must respond instantly if it is to follow the signal impulses and so give the desired short and accurate timing. These tubes are available in ratings suitable for controlling nearly all sizes of resistance welding machines.

THE "AIRADIATOR"

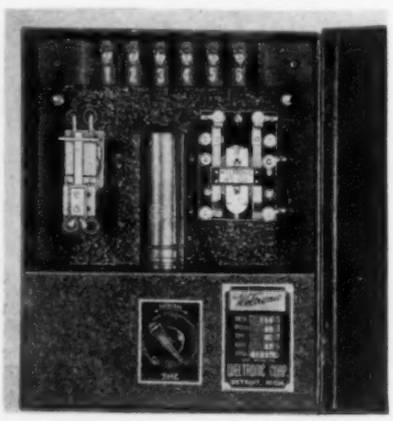
The overheating of welding torch nozzles has caused many troublesome hours to operators when working on light gauge metals in confined areas, or on very heavy castings or metal thicknesses. A water bucket was usually the only feasible precaution against torch "popping, hissing or backfiring," when the nozzle had to perform in confined spaces, such as are encountered in certain aeroplane structures, refrigerating coils or heavy castings.

Victor Equipment Company with headquarter offices at 844 Folsom St., San Francisco, now advise that they are ready to market an air-cooled welding torch nozzle called the "Airadiator." As the name suggests, it is a radiator-like section, made out of aluminum and provided with disk-like fins.

This radiating device is made out of aluminum and the company advises that even in severe field tests and on most difficult operations, no problems have arisen which prevented the maintenance of the desired flame characteristics.

LOW COST GENERAL PURPOSE TIMER

A new, low cost, general purpose timer, capable of providing extremely accurate automatic timing control for virtually any requirement where cycling or sequencing must be controlled in seconds or fractions of seconds, is announced by Weltronic Corporation, 3098 East Outer Drive, Detroit, Michigan.



The new timer Model 52, depends for its accuracy, long life and trouble-free operation upon the electronic principle of timing which employs a vacuum tube as the essential timing element. The use of this, it is claimed, eliminates any inaccuracies which might possibly develop as a result of wear in gear trains, cams and other mechanical timing mechanisms. Once set to the required time control, the electronic type timer never varies, it is said.

Feature of this timer is the rapidity of adjustment afforded by the selector knob by which the operator may set the timer by merely "dialing" for the correct time. This can be done whether the front of the timer is open or closed.

While the range of timing operation can be specified as required for individual uses, this timer has an unusually wide range for its type, the limits being from $^1/_{30}$th of a second to 120 seconds. The timer is available for 110 or 220 volts and for any commercial frequency.

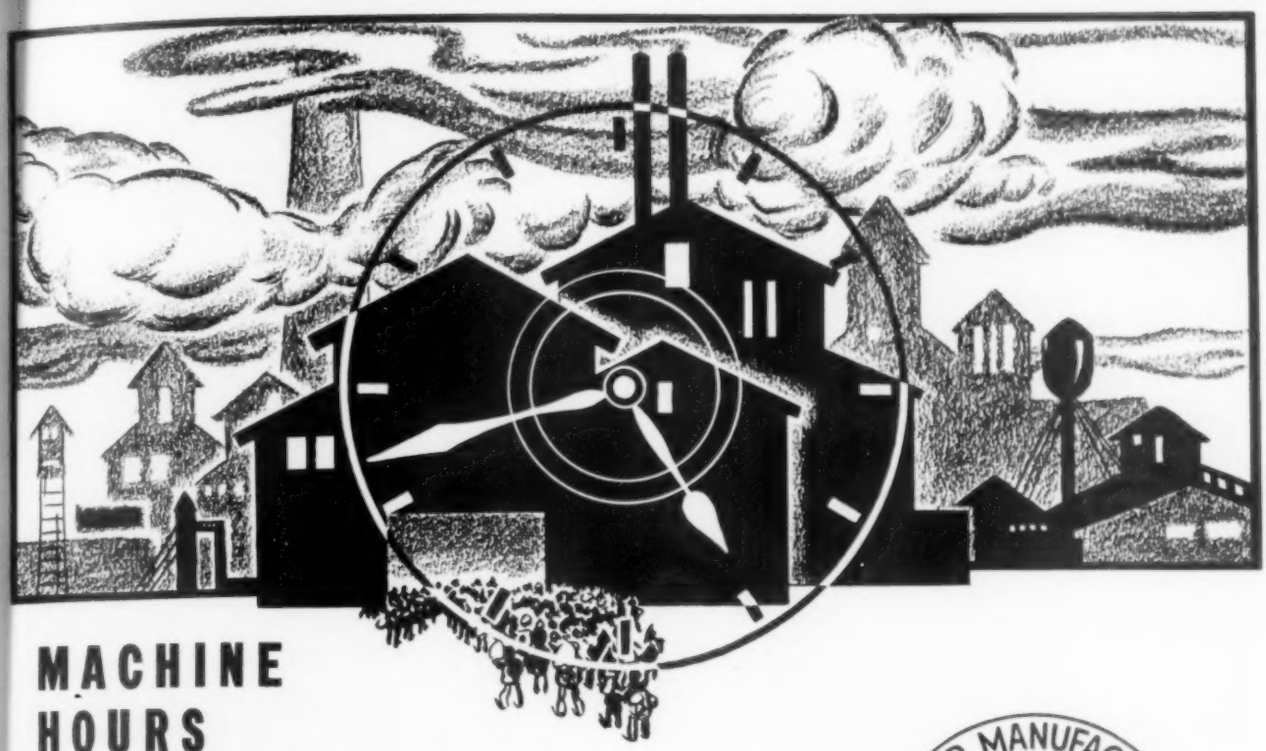
TWO NEW WELDING MACHINES SPEED DEFENSE HOUSING PROGRAM

Made necessary by the defense housing program and having a combined production total of 2400 lineal feet of Stran-Steel members per hour under present operating methods two new multiple-spot welding machines designed and built by Progressive Welder Company, 3034 East Outer Drive, Detroit, Michigan, were recently placed in operation at the Jackson plant of the Stran-Steel Corporation.

Fig. 1—One of Two Progressive Spot-Welding Machines Capable of Spot Welding a Total of Upward of 2400 Lineal Feet of Stran-Steel Framing Members per Hour Employs Twelve Vertically Opposed Sliding Contact Guns Short-Coupled with Six Transformers Mounted in the Base and Sides of the Machine

Previously riveted and later spot welded by means of a single spot machine, the entire line of Stran-Steel joists, studs, half studs and narrow studs of light gage copper bearing steel is first formed into angles or channels and then so joined as to provide a nailing space along the entire

FIFTEEN YEARS PROGRESS BY RESISTANCE WELDING



MACHINE HOURS

Machine Hours are the focal point of industry's efforts towards utmost efficiency—to get the maximum amount of machinery running the maximum number of hours. Complete accomplishment of this objective requires coordination of all phases of production . . . coordination that involves the stepping up of many processes to match accomplished speed in others.

The amazing progress of Resistance Welding during the past fifteen years has offered unique advantages in this respect. While providing advanced welding machines for faster, improved metal fabrication, at the same time, many complicated or difficult manufacturing steps of different nature have been improved or eliminated. For example, the rapid joining of two or more simple stampings by this method has replaced countless intricate, troublesome stampings. This is the type of development that opens the way for smoothly functioning, all-out production—maximum Machine Hours.

Consult any of the member companies listed here. They have experienced engineers available who can show you what results Resistance Welding can accomplish in your plant.

RESISTANCE WELDER

MANUFACTURER'S ASSOCIATION

505 Arch Street Philadelphia, Pa.

RESISTANCE WELDER MANUFACTURERS ASSOCIATION • RWMA

MEMBER COMPANIES

Swift Electric Welder Company, Detroit, Mich.
Taylor-Hall Welding Corporation, Worcester, Mass.
Taylor-Winfield Corporation, Warren, Ohio
Thomson-Gibb Electric Welding Co., Lynn, Mass.
Welding Machines Mfg. Co., Detroit, Mich.
Acme Electric Welder Company, Huntington Park, Calif.
Eisler Engineering Company, Newark, N. J.
Expert Welding Machine Co., Detroit, Mich.
Federal Machine and Welder Company, Warren, Ohio
Multi-Hydromatic Welding and Manufacturing Co., Detroit, Mich.
National Electric Welding Machines Co., Bay City, Mich.
Progressive Welder Company, Detroit, Mich.

ASSOCIATE MEMBER COMPANIES

P. R. Mallory and Co., Indianapolis, Ind.
S-M-S Corporation, Detroit, Mich.
Electroloy, Inc., New York City
Welding Sales and Engineering Co., Detroit, Mich.

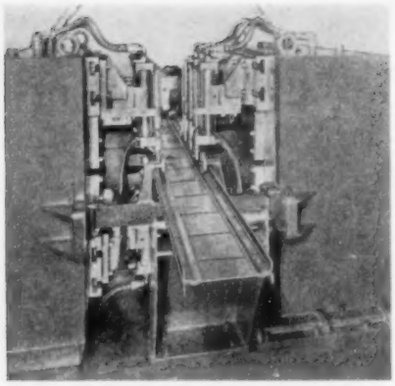


Fig. 2—Welds Are Located When Bubbles, In the Underside of the Channel Section, Drop Onto Guide Rolls. Adjustment for Various Width Shapes as Well as for Distance Between Welds Is Provided

length of each member. The projection formed by bubbles stamped at regular intervals along one half of the completed section provides this nailing space.

Two identical machines each employing twelve vertically opposed sliding contact guns and six welding transformers (one for each spot weld made) are used. An air-hydraulic booster with a large reservoir and high-pressure capacity is actuated by air to supply sufficient hydraulic pressure for the simultaneous operation of the 12 guns.

To accommodate any of the various width Stran-Steel members, provision is made for adjustment as to distance between guns on each side. Guns may be moved also for the proper spacing between spots longitudinally. This, together with the provision made for cutting out the guns on either side (permitting the machine to be used for welding the half stud members), makes each machine capable of welding any of the Stran-Steel sections.

Since the varying gages of metal (joists, for instance, are made up in 11, 12, 13, 14 and 16 gages) require different welding pressure, weld time and welding current, provision for adjustment of each is made.

WELDED VESSELS—BY THE CARLOAD

An excellent example of the application of welding to petroleum refinery equipment is shown in the accompanying photograph of 16 sizes of pressure vessels for a mid-continent refinery, manufactured by the Vulcan Steel Tank Corporation, of Tulsa, Oklahoma. The all-welded vessels range from 150 lb. to 500 lb. working pressure, and all are built to A.P.I.-A.S.M.E. code and inspection requirements.

Arc welding of pressure vessels not only provides seams from 25 to 55% stronger than riveted joints, but the cost of welding is usually less than that of riveting.

NATIONAL TIMERS

A most interesting and instructive bulletin has just been issued by the National Time & Signal Corporation, 600 E. Milwaukee Avenue, Detroit, Michigan. This eight-page booklet gives complete technical details and illustrations in regard to the various timers put out by this company. Reference is given to special timers for stainless steel resistance welding. There are also timers for regular spot welding operations and interrupted multispeed and other timing devices. All those interested in resistance welding timing operations should have available a copy of this booklet.

Employment Service Bulletin

POSITION VACANT

Wanted—Consultant in connection with welding high-pressure welded steel penstocks. Must be expert in the selection of suitable steels for welding and other metallurgical problems involved.

SERVICES AVAILABLE

A-395. Electric Arc Welder. Two years' experience in all positions. Worked for Sun Shipbuilding. Age 24. Willing to start at nominal salary anywhere.

A-396. Welding Engineer, college graduate, first-hand experience in design of welded constructions, solving welding shop problems, improving welding and flame-cutting methods, automatic welding, physical tests, X-ray inspection, thermal treatment, conversant with code work, now designer-draftsman with plate fabricating company, desires change.

A-397. Graduate of New England Schools of Practical Training, completing a four months' day course in Acetylene and Electric Welding, totaling 280 hours, of which 40 hours were spent on Acetylene, the remainder on Electric Arc Welding. Single. Willing to work anywhere in the United States. Can furnish excellent references from all former employers.

A-398. Gas and Electric Welder with six months' experience.

A-399. Welder desires position. Have just completed an intensive 300-hour course in Arc and Gas Welding at the New York Trade School. Have also attended lectures on Welding Metallurgy. 26 years of age. 6 ft. tall, weigh 170 lbs., good physical condition and willing to go anywhere.

LUKENS PROMOTES THEISINGER

William G. Theisinger, who since 1935 has been welding and Metallurgical engineer of Lukens Steel Company, Coatesville, Pa., has been appointed Director of Welding Research of the concern.

Dr. Theisinger was born in Carlisle, Pa., in April 1904. Upon completing his education in the Harrisburg, Pa., public schools, he joined the Harrisburg Steel Corporation where he served until 1925. At that time he became associated with the Board of Transportation of the City of New York in the development of welding inspection.

W. G. Theisinger

In 1930, Dr. Theisinger entered Harvard University from which he graduated in 1934 with the degree of Bachelor of Science. During the summer of 1934 he served the Western Pipe and Steel Company of California as Consulting Engineer on high-amperage, automatic welding. In 1935, after completion of post-graduate work at Harvard, he received the degree of Doctor of Science.

Dr. Theisinger is a member of the AMERICAN WELDING SOCIETY, the American Institute of Mining and Metallurgical Engineers and the Harvard Club of Philadelphia.

Photo courtesy Metal & Thermit Corporation

Welded Pressure Vessels Loaded on a Special 65-Foot Car

Simplify your Welding Problems

WITH U·S·S SPECIAL STEELS

HERE are the special steels that actually contribute to the greater efficiency of rolled steel design and construction.

Special steels for special jobs—that allow you to add strength, without adding weight — providing extra resistance to corrosion, heat, wear, impact, vibration or abrasion in the vital spots without extra costs. You can accomplish all these things with U·S·S Rolled Steels. If you need help, if you have a particular problem — let us show you how to put these steels in your equipment where they will do the most good. Our organization stands ready at all times to help you. Write today for more complete information—or ask one of our steel experts to call.

It will pay you to investigate the advantages of the special steels we offer for rolled steel construction.

U·S·S Cor-Ten to resist corrosion.

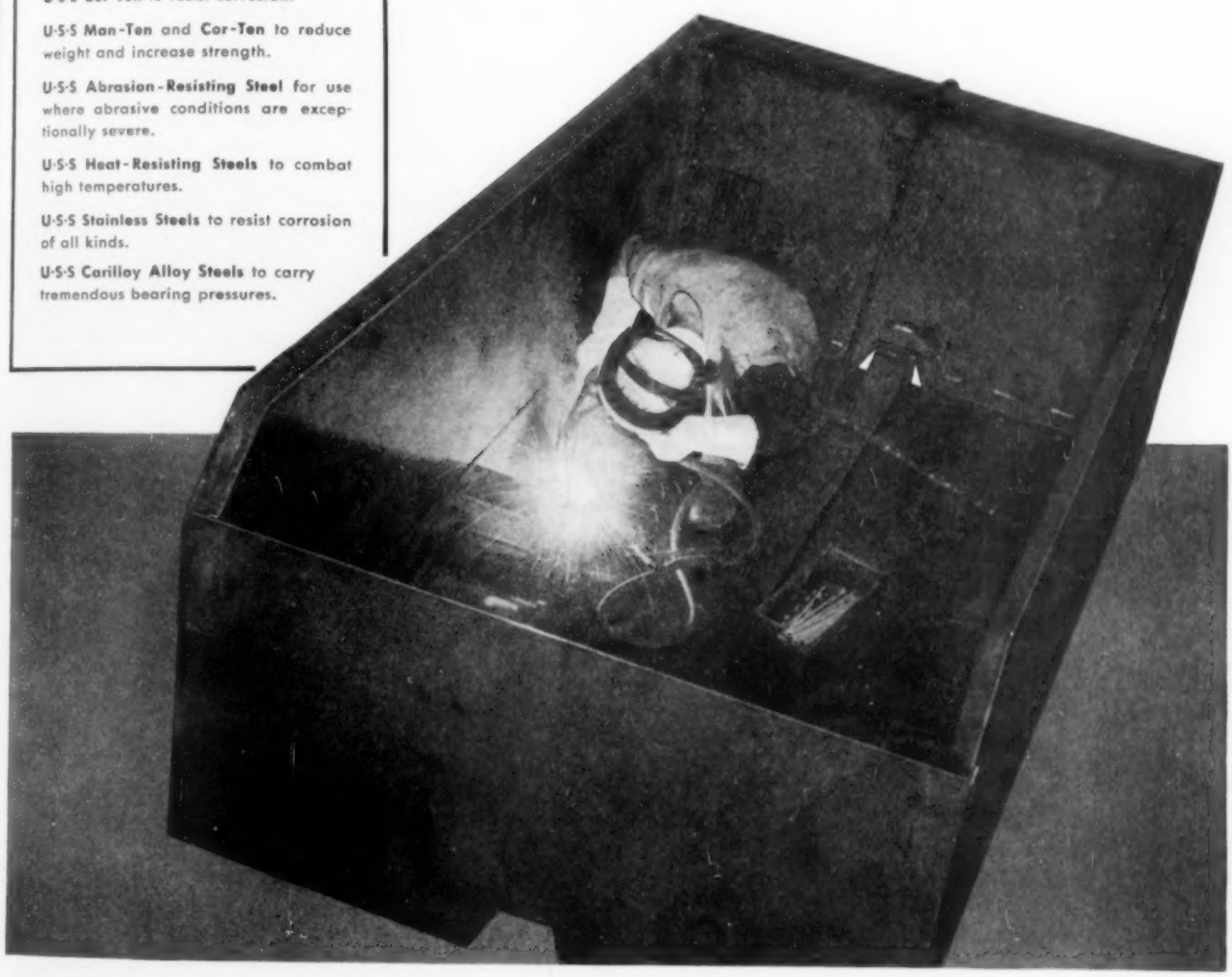
U·S·S Man-Ten and **Cor-Ten** to reduce weight and increase strength.

U·S·S Abrasion-Resisting Steel for use where abrasive conditions are exceptionally severe.

U·S·S Heat-Resisting Steels to combat high temperatures.

U·S·S Stainless Steels to resist corrosion of all kinds.

U·S·S Carilloy Alloy Steels to carry tremendous bearing pressures.



CARNEGIE-ILLINOIS STEEL CORPORATION, *Pittsburgh and Chicago*
COLUMBIA STEEL COMPANY, *San Francisco*
TENNESSEE COAL, IRON & RAILROAD COMPANY, *Birmingham*
United States Steel Export Company, New York

UNITED STATES STEEL

SECTION ACTIVITIES

CINCINNATI

The regular monthly meeting of the Cincinnati Section was held on the evening of January 8th at the Engineers' Club. The speaker for the evening was Mr. G. W. Garman of the General Electric Company, and his topic was "Resistance Welding Control." Sixty members and visitors attended this lecture and the lengthy question and answer period that followed the discussion was good proof of the interest shown by all those present.

CLEVELAND

A large number of Cleveland members attending the February 12th meeting at the Mid-Day Club were treated to two interesting talks.

The meeting proper was preceded by a dinner following which J. W. Van den Bosch, Assistant Regional Director, Training Within Industry Division, Council of National Defense, presented a "coffee talk" on the subject of "Ohio's Industrial Manpower Needs." The speaker pointed out the problems which have been created by the National Defense emergency, emphasizing the need for skilled workmen in many fields.

Principal speaker of the evening was Mr. H. C. Esgar, Engineer, Stainless Steel Division, Carnegie-Illinois Steel Corporation, Pittsburgh, Pa. His subject, "Welding of Stainless and Alloy Steel," is one in which wide interest is being shown due to the growing use of stainless steel in a wide variety of applications, particularly in National Defense production.

Arrangements are being completed for what promises to be a very interesting program for the April meeting. This program is to be called "Weldformation Please." Selection of "experts" is practically completed by the program committee and requests have already gone out to members for questions and problems to be used. From these, the committee will select questions which are to be put up to the "board of experts" at the meeting.

COLUMBUS

An Ohio State Student Chapter affiliated with the Columbus Section of the AMERICAN WELDING SOCIETY has been formed with the following officers: President, Emory Hecox; Vice-President, Edwin Beyer; Secretary, Howard Cary; Treasurer, Thomas Broughton.

At the first regular meeting of this chapter, Mr. Clay Roberts, one of the charter members of the Columbus Section, related his experiences with welding at the Columbus shops of the Pennsylvania Railroad. The Junior Dean of the college of engineering, Mr. W. D. Turnbull, addressed the group, informing it of the Arc Welding Scholarship offered each year to a junior and a senior in welding engineering.

At the second meeting on January 29th, Mr. C. J. Holslag of the Electric Arc Cutting and Welding Co. spoke on welding in general and the advance made by preheating, welding, normalizing in particular.

At the February 14th meeting of the Columbus Section, Mr. J. H. Deppeler of the Metal & Thermit Corporation presented an interesting discussion on "Thermit Welding and Its Applications."

The next meeting of this Section will be held on March 14th at the Hotel Fort Hayes. Mr. K. L. Hansen of Harnischfeger Corp., will speak on "The Electric Arc as a Welding Tool."

The April meeting will be a dinner meeting on the 11th at the Hotel Fort Hayes. Mr. H. O. Jones of the Air Reduction Sales Co. will speak on "Oxyacetylene Welding and Allied Processes."

The May 9th meeting will be at the Battelle Memorial Institute. Mr. R. F. Wyer of the General Electric Co. will speak on "Atomic-Hydrogen Welding."

DETROIT

The fifth meeting of the season was held on February 7th at the Detroit Leland Hotel. Mr. Leon C. Bibber, Welding Engineer, Carnegie-Illinois Steel Corp., spoke on the subject, "The Elements of Welded Design." Mr. Bibber's subject dealt with rigid connections, flexible connections, box girders, three-way connections, tangency, structural connections, insert plates, etc. Members of the American Institute of Architects, American Society for Civil Engineers, Structural Steel and General Contractors Association and Steel Plate Fabricators were invited to attend.

The Flint River Division of the Detroit Section held a meeting on February 10th at the General Motors Technical Institute. Mr. R. T. Gillette, Welding Engineer, General Electric Company, addressed the meeting on "Resistance Welding in Your Plant." Mr. Gillette outlined clever jig and fixture designs, maintenance procedures, values of controls and the like. In addition, a slow motion picture of what actually takes place in a flash weld was shown.

The following are the meeting schedules and subjects for the Detroit Section: March 7th, Detroit, "Stored Energy Welding;" April 4th, Detroit, "Resistance Welding Electrodes;" April 25th, Welding Conference, and April 26th, Michigan State College; May 2nd, Detroit, Past Chairman's Night, Ladies' Night.

The Section has sent out to its membership a questionnaire to ascertain their wishes in regard to the type of meetings they are most interested in.

LOS ANGELES

The Los Angeles Section held their first meeting for the year 1941, on January 23rd, at which time Mr. Chester Mott, Manager, Research Development Dept. for the National Cylinder Gas Company, spoke on "Alignment without Welding Jigs." A paper entitled, "Flame Machining Control and Applications," written by G. L. Walker and W. G. Sylvester, was also presented. Both papers represent very interesting and modern application in the industry.

Very interesting slides accompanied both lectures.

Mr. Seltzer recently assisted Mr. David Bisbee at the last plant inspection meeting of this Section. Through the efforts of these two men, the Society had a most instructive visit through this modern plant and Rheem went to considerable trouble and expense to make this meeting a success. The plant kept about 50 men doing 3 or 4 hours overtime so that all production plants would be operating.

MARYLAND

The following is the schedule for the March and April meetings of the Maryland Section.

March 21st—Mr. E. W. Deck, The Linde Air Products Company. Mr. Deck will present a talk on their "Application Engineering Department's Recent Developments in Oxy-Acetylene Processes and Equipment." Mr. Deck's talk will have special reference to flame priming. He will also present a short film on the "Unionmelt" process.

April 18th—Dr. John W. Miller, Chief Metallurgist, Reid Avery Company, Dundalk, Maryland. Dr. Miller will talk on "The Manufacture and Processing of Welding Rods." Dr. Miller's talk will cover this subject from the raw materials stage to the finished product.

MILWAUKEE

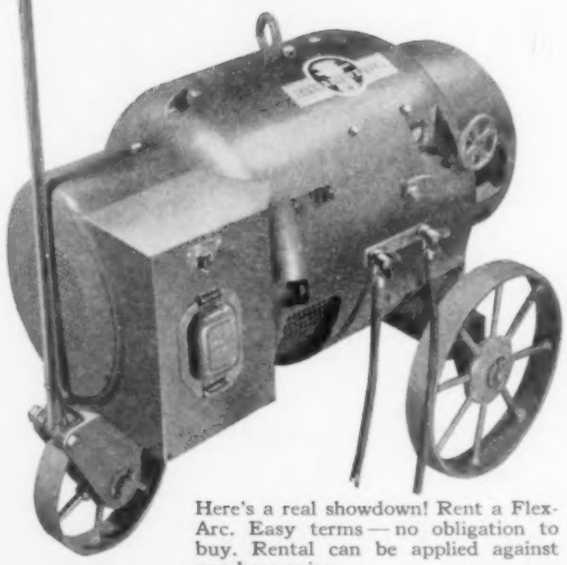
National President's Night was held on Friday, January 24th, at the Cudworth American Legion Post. An after dinner talk was given by Mayor Carl F. Zeidler of the City of Milwaukee. The Welding Address was presented by Col. G. F. Jenks, President, AMERICAN WELDING SOCIETY, and U. S. Army Ordnance Dept. Colonel Jenks spoke on "Welding of Ordnance Structures."

Mr. H. W. Butterbaugh of the American Brass Company spoke at the February 28th meeting on "High Spots in Copper Alloy Welding."

Before you Buy any Welder

MAKE THE FLEXARC 200 FOOT TEST

JUST PRE-SET ONE CONTROL
THEN MOVE ON TO THE JOB AND WELD
200 FEET OR SIMILAR LONG CABLE RUNS. THERE'S NO RUNNING BACK TO A FLEXARC FOR READJUSTMENTS.



Here's a real showdown! Rent a Flex-Arc. Easy terms — no obligation to buy. Rental can be applied against purchase price.

See your FlexArc dealer today and tell him you want to make the FLEXARC 200-FOOT TEST. Then be prepared for a new thrill in arc welding.

Pre-set FlexArc's one control—step away 200 feet, or any distance you choose—and strike your arc.

See what a rock-steady arc FlexArc gives you. Note that there's no need to return to the welder for readjustments—either immediately after warm up, or for different positions of the rod. FlexArc controls the arc for you—perfectly, and automatically.

Here's the capacity to lay metal faster than you ever did before—to spend 60 seconds of every minute welding, not walking—to make better welds because the arc is always right. Isn't that exactly what you want in a welder? . . . then try the 200-FOOT TEST.

WESTINGHOUSE ELECTRIC & MFG. CO.
DEPT. 7-N EAST PITTSBURGH, PA.

J-21058

Westinghouse Flexarc Welders

WESTINGHOUSE ELECTRIC

NEW YORK

A joint meeting of the New York Section of the AMERICAN WELDING SOCIETY and the Metropolitan Section of the American Society of Mechanical Engineers' Iron, Steel, Welding Division, was held on Tuesday, February 11th in the Auditorium of the Engineering Societies Building. Dr. James C. Hodge, Vice-President and Director of the Wellman Engineering Company presented an exceptionally interesting lecture on "Pipe and Pressure Vessel Welding." The lecture covered welding requirements for conformance to published codes; procedures and shop practices; testing and inspection, as well as the metallurgical aspects of problems encountered and relation of alloy steels thereto.

A joint meeting with the American Society of Civil Engineers will be held on March 19th. Col. G. F. Jenks, U. S. Army Ordnance Dept. and President of the A. W. S. will tell how and where our industry can serve to the greatest extent in the National Defense Program.

"Improvements in Welding by Means of Preheating" will be the subject for the April 15th meeting.

Subject and other information on the May 6th meeting will be announced later.

NORTHERN NEW JERSEY

The regular meeting of this Section was held on January 21st in the Oxford Room of the Essex House, Newark. Mr. J. H. Deppeler, Chief Engineer of the Metal and Thermit Corp., presented an interesting non-technical description of the fundamental principles of the thermit welding process and of the techniques employed in its application. The utility of the process for making repairs to heavy sections, with special reference to shipyard work and steel mill repairs, was described and illustrated. The production possibilities of the process were shown in its application to the welding of railroad rails into continuous lengths.

Supplementing this paper on thermit welding, Mr. Deppeler gave a talk on the design of arc welding electrodes. This discussion explained the difference between the different types of electrode coatings, the general purpose of coatings on electrodes and other subjects.

The second speaker of the evening was Mr. C. J. Holslag, Chief Engineer of the Electric Arc Cutting & Welding Co., who spoke on "Improvements in Welding by Means of Preheating." How preheating methods solve welding problems that arise in the construction of high-pressure steam lines where special alloy steels are used, furnished an interesting introduction to a paper which described in detail some very late developments in preheating practice.

At the February 18th meeting a motion picture, "Welding on the New Union Airlines Terminal Building," in technicolor, showed the complete story of the shop fabrication and field erection of the framework of New York's newest showplace. Close-ups show the welding of typical details. The film was shown through the courtesy of Air Reduction Sales Co.

Mr. LaMotte Grover, Structural Welding Engineer, Air Reduction Sales Company, spoke on "Structural Steel Welding."

Mr. E. P. Jones, The Linde Air Products Co., spoke on "Oxy-Acetylene Gouging."

A Welders' Exhibit is to be held in the Terrace Room of the Mosque Building, Newark, on March 21 and 22, 1941. Manufacturers of welding equipment and material will have their latest offerings on display. The exhibit will be open to all who are interested in welding operations of any kind.

NORTHWEST

The January meeting of the Northwest Section was held on the 9th in the Coffman Memorial Union, University of Minnesota. Mr. Elmer E. Isgren, Plant Superintendent, R. G. LeTourneau Inc., addressed the meeting on "Construction and Fabrication." Mr. Isgren introduced his talk with a sound film showing LeTourneau's Tournapull in action in the field on specific projects throughout the states. By method of slide film Mr. Isgren brought his talk into the LeTourneau shops at Peoria and California, discussing welded construction and fabrication.

Phil Brain's motion pictures of the 1940 Golden Gophers football games were shown after the meeting.

OKLAHOMA CITY

The following is the program for the remainder of the season for the Oklahoma City Section.

April 10—6:30 P.M.—"Procedure Control of Welding," by O. T. Barnett, Metal & Thermit Corp. (Dinner Meeting.)

May 8—8:00 P.M.—"Hard Surfacing," by E. F. Smith, Haynes Stellite Co.

June (to be announced)—Résumé of year and report of officers. Refreshments.

PEORIA

Newly elected officers of the Peoria Section for the coming year are as follows: Chairman, Walter J. Brooking, R. G. LeTourneau, Inc.; Vice-Chairman, Clifford Wimmer, Keystone Steel & Wire Co.; Secretary, Albert A. Losch, R. G. LeTourneau, Inc.; Treasurer, Robert Rutledge, A. Lucas & Sons. Executive Committee to serve for 2 years: J. F. Reist, Elmer Isgren, W. W. Wilkerson.

At the February 5th meeting, Mr. W. A. Pearl, Armour Institute of Technology, was the guest speaker at the Central Illinois Light Company auditorium. His subject was "The Metallurgy of Arc Welding," and the talk was accompanied by a motion picture, "Asbestos."

The March meeting held on the 5th had Mr. L. M. Keating, Manager, Special Products Division, A. O. Smith Corporation, as speaker. Mr. Keating's subject was on "Welding and Mass Production of Special Products." A motion picture, "Safety Glass," was also shown.

The April meeting will be held on the 2nd. Mr. Eric Seabloom, Research and Development Engineer of the Crane Company, will speak on "Hard Facing—Its Use and Application." A motion picture, "Oil Lands of Europe and Africa," will be shown.

The May meeting will be held on the 7th. This is to be a dinner meeting, place to be announced. "The Application of Arc Welding to Modern Military Equipment" will be presented by W. F. Schmitt, Welding Technician, Rock Island Arsenal. A motion picture, "Alloy Steels—a Story of Their Development," will be shown.

PHILADELPHIA

The regular monthly meeting of the Philadelphia Section was held on February 17th. Mr. F. G. Outcault of The Linde Air Products Company spoke on "Unionmelt Welding Process and Its Industrial Application." In addition to a full description of the process Mr. Outcault showed motion pictures covering the latest uses of Unionmelt.

The March meeting will be held on the 17th. Mr. H. W. Lawson of the Bethlehem Steel Co. will speak on "Building Construction by Welding," which will be followed by a round-table discussion.

The April meeting (tentative) will be devoted to Railroad Application of Arc Welding.

In May there will be an inspection trip.

PITTSBURGH

Colonel G. F. Jenks, Ordnance Office, Washington, D. C., and President of the AMERICAN WELDING SOCIETY, will be the principal speaker at the Fourth Annual Tri-State Regional Welding Conference, to be held by the Pittsburgh Section, April 18th in the Wm. Penn Hotel.

The Conference will be held jointly with the Engineers' Society of Western Pennsylvania and both afternoon and evening sessions will be held.

The January 15th meeting of the Pittsburgh Section was in the nature of a Welders' Forum, for the discussion of questions on welding subjects.

A Board of Experts was able to cope very satisfactorily with questions sent in and asked from the floor. In addition much interesting information on various subjects was brought out through discussions by members and guests in the audience.

It has been decided to include a Welders' Forum as a regular meeting in the future due to the success of this first attempt.

PUGET SOUND

Frank B. Bolte, Process Engineer for the Boeing Aircraft Co. and Chairman of the American Society for Metals, Puget Sound Chapter, presented an address, "Welding in Aircraft," at the January 28th meeting of the Puget Sound Section.

George Tepley of the Eagle Metals Co. gave a short talk on Application of Welding on Non-Ferrous Metals.

ROCHESTER

The Rochester Section had the privilege of hearing Mr. John H. Zimmerman, Manager of the Development Department, The Linde Air Products Company, New

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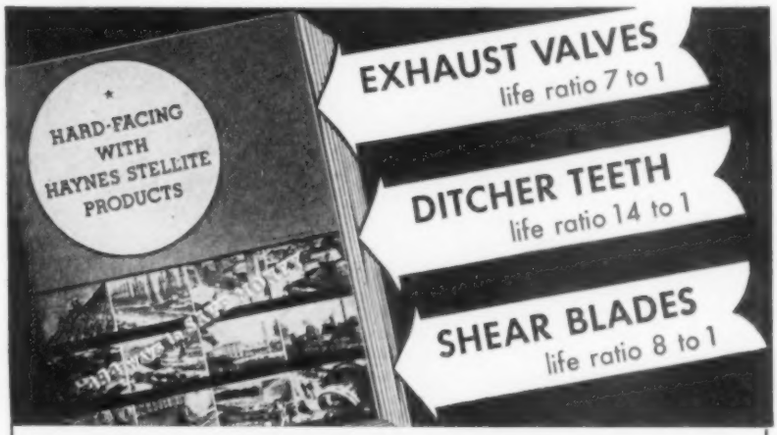

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York, on the subject of "Modern Applications of Flame-Cutting Processes" at the February 6th meeting of the Section.

ST. LOUIS

Mr. Elmer E. Isgren, Chairman of the Peoria Section, and Superintendent of LeTourneau, Inc., presented an interesting lecture with a movie on the subject, "The Manufacturing of Heavy Road-Building Equipment by the Arc Welding Method," at the January 17th meeting of the St. Louis Section.

SOUTH TEXAS

The first meeting of 1941 was held at the Houston Engineers' Club on January 15th, and some one hundred and twenty members and guests were present. The Executive Committee convened at 7 P.M. and elected the following chairmen of active committees: Program Committee, T. D. Ketchbaw; Membership, Malcolm Reed; Periodicals and Literature, E. C. Jackson; Entertainment, B. J. Brugge; New Developments, R. F. Arnoldy.

The regular meeting was called to order at 7:30 P.M. Mr. J. F. Lincoln, President of The Lincoln Electric Company, Cleveland, addressed the Section on "Welding as Used in Manufacturing" and used lantern slides to illustrate various points that were brought out. Following the address questions from the floor and a general discussion brought out several points of current interest regarding welding in connection with the rearmament program.

Mr. E. C. Jackson reviewed last issues of THE WELDING JOURNAL.

At its February meeting held on the 7th at the Houston Engineers' Club, approximately fifty per cent of the membership were present to take part in a lively discussion instigated by local talent. Mr. B. W. Farquhar, past-chairman of the Section, read and discussed a paper on the "Discovery and Development of Arc Welding," and Mr. C. C. Goolsbee, Welding Engineer of the Reed Roller Bit Company, reported on the work that is being done by the Texas Employment Service and W.P.A. offices to reclaim welding operators that have not been recently employed in the welding trade.

Mr. R. F. Arnoldy, representative of The Linde Air Products Company, related recent experiments with flame cleaning of steel in preparation for painting.

The Executive Committee held a dinner meeting at the Weldon Cafeteria at 6 P.M., and among other considerations decided to sponsor a series of educational lectures using the recently published "Welding Metallurgy" by O. H. Henry and G. E. Claussen as a text.

TULSA

The first meeting of the new year was held on January 17th at the Mayo Hotel. Mr. F. C. Hutchinson, Division Engineer of The Linde Air Products Co., spoke on the subject, "Recent Developments in Oxy-Acetylene Practices," which was illustrated with motion pictures and slides.

The second meeting was held on January 31st. The three big features on the program were: (1) Mr. Russell Hill, on the subject, "Welding Rod for Use on Material to be Galvanized." (2) Mr. C. H. Louree, on the subject "Fundamental of Welding Design." (3) Mr. Parker W. Patterson with answers to questions previously asked.

A special invitation to attend this meeting was extended to members of the Engineers' Club of Tulsa, fabricators of steel products, and schools of welding.

The February meeting was held on the 7th. Dr. W. C. Theisinger, Director of Welding Research of Lukens Steel Co., Coatesville, Pa., spoke on "Technical Matters Involved in the Application and Fabrication of Steel Products with Reference to Welding." Technicolor motion pictures illustrated Dr. Theisinger's lecture and an added special feature was the technicolor motion picture showing the largest steel plate rolling mill in the world as it functions in the production of steel plates.

WASHINGTON, D. C.

The fourth regular meeting of the Washington Section was held at 8:00 P.M. on January 28, 1941, in the auditorium of the Potomac Electric Power Company. The speaker was Mr. Arthur J. Raymo, Welding Engineer for the Baldwin Locomotive Company. His subject was "Welding in a Large Industrial Plant," which was a considerable departure from the usual technical or semi-technical discussion of welding operations and properties of welds. Mr. Raymo first described the difficulties in getting well-trained welding operators. These come from trade schools, high schools and other industries. Practice at the Baldwin plant is to take the most acceptable of these and give them a training course.

The speaker has recently occupied the enviable position of participating in the construction of a plant for welding without the necessity for modifying existing establishments. Hence the new plant was designed with as many of the best features as were possible to include in it.

The discussion following Mr. Raymo's paper was extremely interesting, indicating that the subject and presentation were enjoyed by all.

WESTERN NEW YORK

The January meeting was held January 27, 1941, at the University Club and started with a dinner which was followed by the regular business meeting.

It was decided to have all future meetings of the section at the University Club and precede them with a dinner to which all members and their guests are cordially invited.

Appointment of Mr. Stuart Rich of Bell Aircraft Corporation as chairman of the Membership Committee was announced.

The speaker of the evening, Mr. E. W. P. Smith of The Lincoln Electric Company, gave an excellent and interesting talk on "Cost Reduction and Procedure Control." The talk was illustrated by means of celluloid models and polarized light and was highly impressive and instructive.

YORK-CENTRAL PENNSYLVANIA

About ninety men braved the elements to hear Mr. F. H. Miller speak on the subject "Trends of Arc Welding in Industry," at the January 15th meeting of the York-Central Pa. Section. Mr. Miller is Superintendent of the Welded Products Department of the General Electric Co., Schenectady, N. Y. His talk was illustrated with very interesting slides showing some of the various types of welding jobs performed in his plant. An added attraction was a slow motion picture of weld metal being deposited. This talk provoked a great deal of interesting discussion.

List of New Members

December 1st to December 31, 1940

BIRMINGHAM

Curry, Don H. (D), 1224 No. 31st St., Birmingham, Ala.

BOSTON

Kiley, Henry E. (C), Mass. Inst. of Tech., Cambridge, Mass.

Robinson, John B. (C), General Accident Fire & Life Assn. Co., 10 Post Office Sq., Boston, Mass.

CANADA

Pendlebury, George T. (D), Canadian Pacific Railway, 1426 Lincoln Ave., Winnipeg, Manitoba, Canada

CANAL ZONE

Romanek, Ferdinand (D), Box 1364, Balboa, Canal Zone.

CHATTANOOGA

Farmer, C. W. (D), Center, Alabama.

CHICAGO

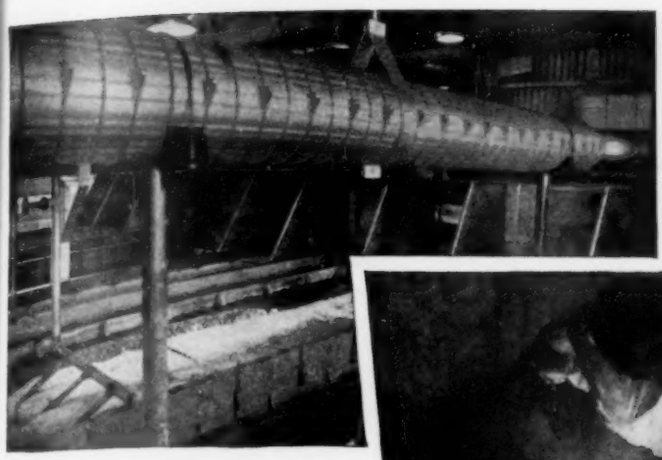
Bernard, Art (C), The Linde Air Products Co., 9043 So. Paulina St., Chicago, Ill.

Matis, Henry A. (C), 549 E. 91st St., Chicago, Ill.

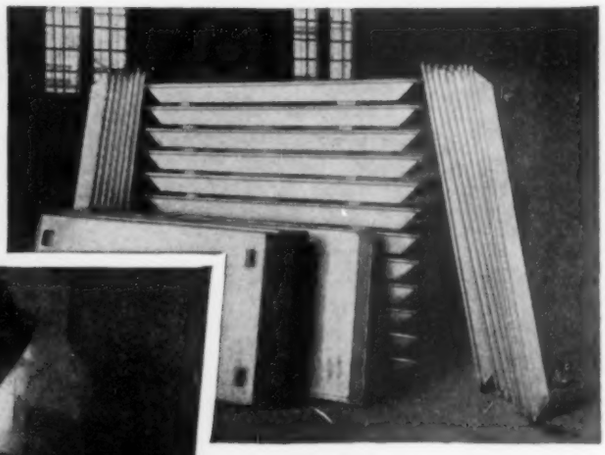
Peterson, A. C. (B), Geo. B. Limbert & Co., E. Chicago, Indiana.

CINCINNATI

Gabriel, William (D), 1726 Pulte St., Fairmont, Cincinnati, Ohio.



PAPER STOCK TROUGHS: A large southern Kraft mill made three 60-foot long x 24" x 26" stock troughs from 16 gauge Monel sheet. In each trough, 2 longitudinal welds, 5 girth welds and 2 end welds were made. No. 130X Monel rod was used throughout.



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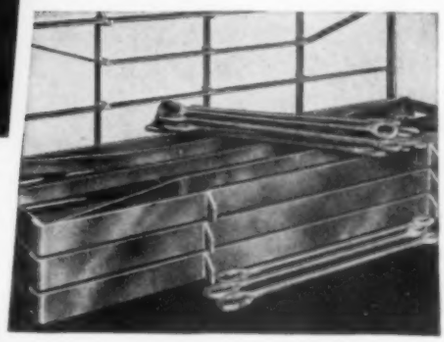

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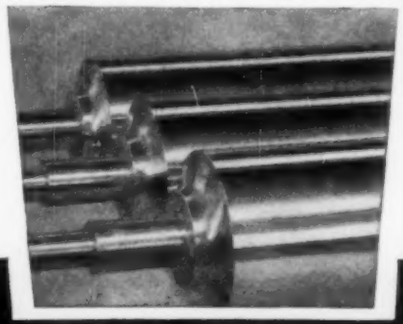

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Brugler, Richard L. (F), 290 E. Lane Ave., Columbus, Ohio.
Feldman, Bill (F), 220 West 10th, Columbus, Ohio.
Hendricks, Walter E. (F), Ohio State Univ., Tower Club, Columbus, Ohio.
Johnson, J. R. (F), 2174 Summit St., Columbus, Ohio.
Kadis, Simon (F), 1609½ Highland St., Columbus, Ohio.
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Duchemin, Gus (D), Sheridan, Indiana.
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Rogers, Clifton V. (C), 314 Dixie Dr., Towson, Md.

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Krassner, George (D), Ardsley, New York.
Martini, Charles (D), 252—74th St., Brooklyn, N. Y.
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Moravec, Charles (C), 135 Elliot Place, Bronx, N. Y.
Morgese, James (B), 150-54 New York Blvd., Jamaica, N. Y.
Oberst, Hugh J. (D), 5060—45th St., Woodside, L. I., N. Y.
Plichta, Leon A. (D), Box 82, Port Reading, N. J.
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Sheehan, P. C. (D), 2588 Creston Ave., Bronx, N. Y.
Silldorff, Henry C. (C), 50 Green Village Rd., Madison, N. J.
Wilson, Newell J. (C), 3912—51st St., Woodside, N. Y.

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Gottlieb, Seymour (D), 305 Reynolds Terrace, Orange, N. J.
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Person, Dewey (D), 721 Monroe Ave., Plainfield, N. J.
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Kane, James C. (D), 1503 Rugby Rd., Schenectady, N. Y.
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Livingston, Eugene (D), Box 63, Mendota, Calif.
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Burkett, George A. (D), 2423 Wilcox Ave., Youngstown, Ohio.
Clark, L. A. (D), 220 S. Merser St., Greenville, Pa.
Cook, Harry W. (C), Westinghouse E. & M. Co., 438 Ohio Edison Bldg., Youngstown, Ohio.
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Hamp, C. H. (D), 914 Glenwood Ave., N. E., Warren, Ohio.
McCright, Paul H. (D), R.D. 3, Greenville, Pa.
Shugarts, Blair D. (D), 412 So. Pearl St., Youngstown, Ohio.

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Boyd, Henry I (D), P.O. Box 233, Hilton Village, Va.
Evarts, Stanley T. (D), 257 E. Third St., Corning, N. Y.
Hamilton, Samuel L. (B), P.O. Bin 3, Stuart, Fla.
Nafzger, Edwin (B), Toledo Steel Tube Co., 2105 Smead Ave., Toledo, Ohio.
Vanbiesem, Francisco (B), La Autogena S.R.L., Tacuari 1959, Buenos Aires, Argentina.

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(*Continued from page 188*)

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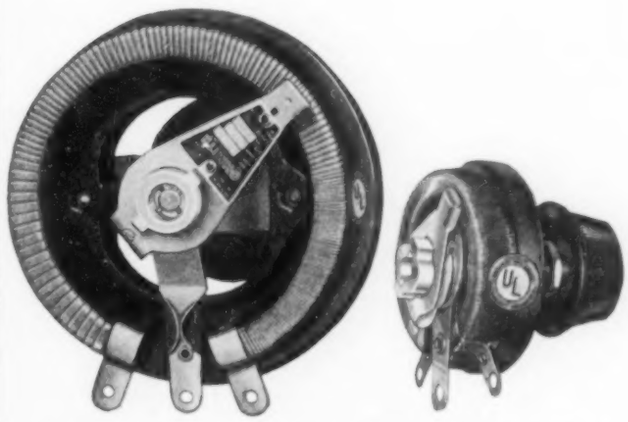

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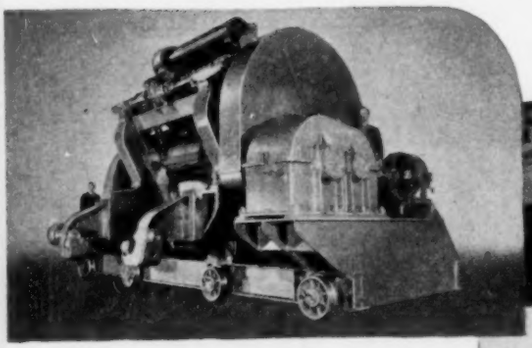

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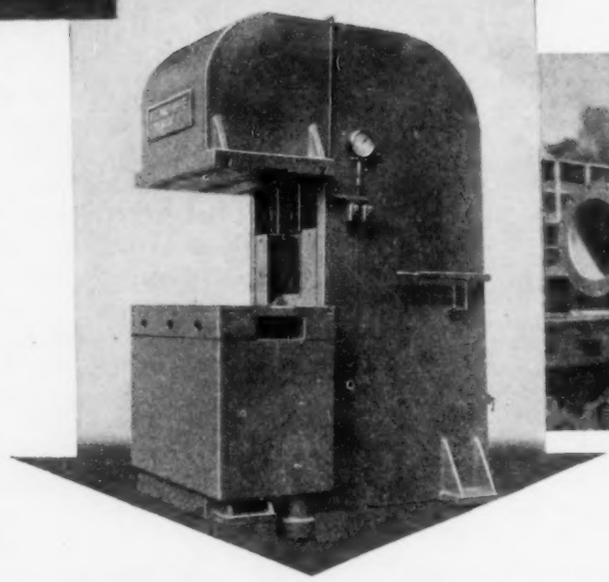

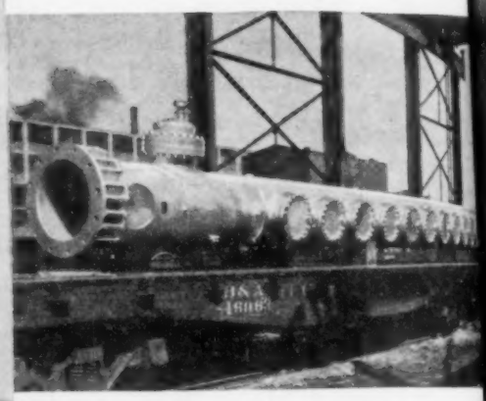

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